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PROGRAM MANAGEMENT

SUMMARY

Major Milestone Completions

The service module for mock-up 9 (spacecraft handling and transportation) was structurally completed during this period, and further effort was continued on systems installation in mock-up 11 (spacecraft handling and transportation) and mock-up 2 (cabin interior arrangement). The 100-percent design release of boilerplate 9 (dynamic test article) was rescheduled for November. Initial assembly operations were started on beam structures for the first aluminum service module to be used for dynamic tests of boilerplate 9. Other significant boilerplate activity was highlighted by the start of assembly operations on articles 6 and 9, which increased the number of boilerplates in work to five.

Major PMP completions for this period were the design of the service module boilerplate separator system (service module structure and subsystem installation) and the design and development of a parachute test vehicle (earth-landing subsystem). The PMP general order milestone lists have been reviewed by NASA and S&ID, and several have been accepted for implementation.

Firm Cost Proposal (30 October)—Cost Reduction

Effective implementation of the cost reduction program was a major effort during the report period. The revised master development schedule and cost reduction exercises were established by program management, and extensive re-evaluations of manpower and expenditure requirements were undertaken by all functional organizations in the Apollo program. These evaluations will establish an acceptable level of design sophistication and testing consistent with the program mission objectives.

Back-up data to support this proposal are being prepared. Revisions of documentation were prepared to support the 30 October proposal which was submitted to NASA on 30 October 1962.

Master Development Schedules

The fifth revision of the master development schedule, dated 12 October 1962, has been adopted. The basic scope of the master development schedule

has not changed since the 18 September schedule. The 12 October revised schedule (Appendix C) contains additional details. Following are revisions to the 18 September schedule.

1. Major milestone reference data. Some drawing release dates have been rescheduled.

2. Boilerplate manufacturing completions. The title of boilerplate 13 has been changed to first spacecraft test vehicle.

3. Airframe manufacturing completions. There are now nine airframes scheduled through the second earth-orbital flight. Airframe 008 was accelerated one month to provide more time for AEDC tests.

4. Associate contractor and subcontractor delivery requirements have been added to the boilerplate and airframe manufacturing completions.

Vehicle-oriented schedules are being developed for display in the Apollo control center.

PERT

A rolling network concept is being adopted by S&ID. This concept will provide for an added level of density during an immediate time period. The level of detail in past and future periods would be more of a summary-type nature. A schedule for reconstruction of PERT networks has been established, and effort is proceeding slightly ahead of schedule. Preliminary drafts of eight reconstructed general order networks have been submitted to NASA for review. The general order milestone lists that have been accepted are being checked against the general order PERT networks. Where milestones are not included as events, the networks are being amended. A seven-digit PERT event numbering system has been established and agreed to by NASA and S&ID. The basic system for PERT associated cost reporting has been developed. S&ID has worked out the details and, through the use of pilot runs, checked the validity and usefulness of this information.

PLANS

The revised program plan, which is consistent with the 12 October 1962 master development schedule, is scheduled for submittal during the next

period. Every effort has been made to incorporate NASA comments on previous program plans into this revision. A meeting with NASA has been scheduled for early November to discuss the Apollo support plan. General criteria and guide lines for operating procedures will be developed. The status of the logistics support program will be discussed. The format of the GSE planning and requirements document is being changed to show utilization of all GSE. This document will be utilized by NASA in the development of GSE budget and planning estimates. The Apollo test plan has been reviewed by NASA and S&ID. Modifications to the plan are being developed as a result of this review. The review of other Apollo plans, which was scheduled for late October, has not been completed. Draft revisions to the Apollo plans are used as supporting documents for the 30 October firm cost proposal.

CONTROL CENTER

Major modifications to the Apollo control center have been made. Basic construction has been completed, and the displays have been oriented toward a more useful format. It is planned that the displays in the room be broken down into the following categories:

1. Hardware. These displays will be associated to specific end items such as boilerplates, spacecraft, and mock-ups.

2. Configurations and schedules. Status against each end item will be split. Manpower, cost, and PMP milestones of general orders will be statused against this alignment. Because procurement is aligned to the general order structure, major subcontractor status will be reported against this alignment.

3. Functional. Departmental activities will be summarized in this section. Indicators such as manpower and schedule status will be displayed.

Comprehensive discussion of the control center will be included in the revised program plan.

ASSOCIATE CONTRACTOR ADMINISTRATION

S&ID is preparing for discussions with NASA and the Lunar Excursion Module contractor relative to technical and management coordination during the initial LEM effort. Plans include an orientation program for key employees of the LEM contractor and on-site technical representation from the outset.

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The problem of center crew couch interference with the sextant protective shroud was resolved by changing the couch knee angle from 100 to 98 degrees.

MIT and S&ID have agreed upon the essential requirements for MIT's navigation and guidance facilities at Downey. Each is preparing layouts for further consideration.

A partial mock-up of MIT's navigation and guidance system (AGE 0) was received at Downey on 9 October. The balance of the mock-up, displays, and controls is expected approximately 15 November.

SUBCONTRACT STATUS

Cost reduction exercises were completed with all major subcontractors during the report period. Revised cost proposals were received and are being evaluated.

Changes in process resulting from the cost reduction exercises will result in changed contract definitization target dates.

Subcontractor	Prior Target Date	Current Target Date
Aerojet	November 1962	December 1962
AiResearch	December 1962	December 1962
Avco	December 1962	December 1962
Collins	November 1962	December 1962
Lockheed	October 1962	December 1962
Marquardt	December 1962	December 1962
Minneapolis-Honeywell	December 1962	December 1962
Northrop-Ventura	December 1962	December 1962
Pratt & Whitney	November 1962	December 1962
Thiokol	October 1962	November 1962
Beech	November 1962	December 1962

NEW PROCUREMENTS

An order for Apollo batteries was placed during the report period.

Orders are in process for the following items:

Item	Target Date
Static inverter	7 November 1962
Positive expulsion tanks	15 December 1962
Main propellant tanks	1 December 1962
Battery charger	1 November 1962
Mission simulator	1 March 1963
Propellant utilization tanks	15 December 1962
Central timing system	3 December 1962
Radome	31 December 1962
2 KMC antenna	15 December 1962
Beacon antenna	31 December 1962
In-flight test system	15 January 1963

INTERDIVISIONAL PROCUREMENT

Rocketdyne Division has been assigned the development and production of the reaction control engines for the command module.

Seventy-two items of GSE have been assigned to the Tulsa facility for design and production.

Other divisions of NAA are continuing testing and development support of various programs.

CONTRACT CHANGE AUTHORIZATION/CONTRACT CHANGE PROPOSAL

The Contract Change Proposal 1 on cabin atmosphere was included in the delta proposal. Contract Change Authorization 2 on lunar rendezvous will be proposed by S&ID after negotiations of the definitive contract.

The preliminary Contract Change Proposal for Contract Change Authorization 3 on breadboard fuel cell module was submitted with $140,000 budgetary and planning estimate. The final Contract Change Proposal is in process.

The preliminary Contract Change Proposal for Contract Change Authorization on command module/lunar excursion module docking study is in process. A firm cost proposal is now being prepared for this Contract Change Authorization in place of a preliminary Contract Change Proposal.

The preliminary Contract Change Proposal is in process for Contract Change Authorization 5 on support manuals.

First Change Control Board Meeting

The first change control board meeting occurred 22 October 1962. In the first change control board meeting, the committee began a complete review and discussion of the status of all master changes recorded on Project Apollo. This review developed a basis for introducing engineering changes into the change control board for action.

Service Propulsion Subsystem

A TWX was received from NASA (Contract Change Authorization 7) instructing S&ID to:

a) Implement the technical direction contained in NASA letter of 12 September 1962 pertinent to deletion of the propellant utilization system for the statement of work;

b) Furnish an impact statement regarding this change no later than ten days from receipt of this direction.

S&ID is proceeding to implement the change and prepare a CCP. Engineering will clearly point out the effects of this change on the Apollo program, particularly in the areas of weight, cost, and schedule.

Facilities Long Lead Items

A letter was transmitted to NASA requesting advance approval of several long-lead time items included in Appendix "A" for Apollo facilities. This request has been denied by NASA because of insufficient justification.

Ground Support Equipment - WSMR

A meeting was attended at NASA Houston, on 28 September 1962 on GSE concept for WSMR. The meeting resulted in substantial redirection for WSMR GSE; NASA indicated that full scale design review of engineering drawings would be required prior to approval of any further items of GSE. The redirection of WSMR GSE was forwarded by NASA TWX dated 29 September 1962, signed by J. Thomas Markley. S&ID TWX dated 1 October requested contract change authorization due to possible impact of redirection on WSMR GSE cost and test schedules.

At the September 28 meeting, NASA representatives were advised that detailed drawing review on each item of GSE by NASA prior to release would be exceedingly cumbersome and would result in possible schedule delays. To overcome this problem, engineering and logistics are currently coordinating a GSE provisioning procedure which will subject only high cost GSE items to review by NASA. This review is anticipated to be limited to conceptual design only prior to release to fabrication.

MIT Mock-up Equipment

Arrangements have been made for receipt and handling of MIT mock-up equipment. Receiving department was requested to make arrangements to receive and handle this equipment as Government Furnished Property. They will also establish routines for handling future shipments of this type.

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SPACECRAFT INTEGRATION

CONFIGURATION CONTROL

Airborne Configuration Control

The detailed parts list for boilerplate 1 was revised and released. The list for boilerplates 3 and 19 will be released during the next report period and the list for boilerplate 2 will be started.

GSE Configuration Control

The GSE detailed parts list for boilerplate 1 is revised and released. GSE requirements for boilerplates 2, 3, 6, and 19 are compiled and are being incorporated into the parts list for revision or release.

Interface Control

It has been determined there will be a difference between boilerplate radomes and airframe radomes. A drawing list for boilerplates 3 and 19 is released.

The following drawings are released:

Omniantenna radome to forward compartment

"Q" ball to launch escape ballast enclosure

Launch escape motor to structural skirt

Tower jettison motor to pitch control motor support structure

Tower jettison motor to launch escape motor

The loose equipment drawing will be released.

WEIGHT CONTROL

Command Module

The nominal command module weight was reduced from 9250 to 8760 pounds by incorporating the changes presented to NASA. The center of

gravity offset was greatly improved by relocating the equipment, crew, and couches for the entry phase. The current center of gravity, for the command module at entry, is +8.2 inches on the Z-axis.

Center-of-gravity studies will be conducted which will be aimed at continual weight improvement for the command module.

Service Module

The service module weight was reduced from 11,500 to 10,765 pounds by incorporating the changes presented to NASA. Weight trade-off studies are under way to locate and establish a design concept for the reaction control system (RCS).

Center of gravity and moments of inertia are being determined for the combined service and command modules. These are based on positive, negative, and lateral thrust conditions from propellant tanks full to empty.

General Spacecraft

The design concept of the weighing fixtures for the boilerplates has been established for all modules. Actual measurements of all three centers of gravity in the horizontal attitude will be taken by rotating 90 degrees between measurements on all modules, except for command module Y and Z, which will be made vertically.

As requested by NASA, more detail is now being provided in the monthly weight and balance report. A revised reporting format is being used. Improvements are being incorporated into the machine analysis program to provide a more suitable report-type printout.

COMMAND AND SERVICE MODULE MOCK-UPS

Mock-up 2 is currently on schedule. Ninety-eight percent of the engineering information for Mock-up 12 (Crew Support Equipment) has been released. The Apollo Master Mock-up schedule calls for a mock-up 18 design freeze on 21 September. There are fourteen major areas in which little information is available to support this design freeze because of recent system changes.

CRITERIA REQUIREMENTS

Detailed definitions and objectives were released for boilerplates 1, 2, 3, 19 and 25.

The detail definitions and objectives for boilerplates 9, 13, 15, 16 and 18 will be released.

Fifteen specifications will be released during the next report period.

ENGINEERING PROGRAM INTEGRATION

A study was initiated to define integration criteria and requirements for the in-flight test system, displays and telemetry flow.

A draft of the design criteria for the service module RCS was prepared. This pointed out the implications of the design to the emergency detection system, stabilization control system (SCS) computer, and command module displays and controls.

A briefing on the subject of trajectory and recovery problems resulting from malfunctions in electronic systems was made to the recovery and survival committee.

Studies were conducted to determine the Apollo/Saturn stage station flow, and to establish a preliminary logic network for the operation flow at AMR. An analysis of the RCS, engine selection logic was completed. Results indicate 85 percent of all first and second order engine failures in the selection logic could be compensated for, and spacecraft attitude control maintained. For 15 percent of the possible engine failures, one axis of spacecraft control would be lost with no possible recovery through changes to selection logic.

A mission analysis of service module propulsion contingencies involving use of lunar excursion module propulsion as a back-up engine system was completed. A preliminary mission sequence to establish operational concepts for the lunar orbital rendezvous technique has also been completed.

The technical development plan will be revised during the next report period in accordance with the latest program definition.

The engineering PERT subnetwork for airframe 009 to serve as a model for subnetworks to be built for all boilerplates and airframes will be completed.

SYSTEMS INTEGRATION

A list of propellant and propulsion interface was prepared, and the Apollo interface for Little Joe-II was defined and documented.

Requirements for the launcher-transporter for the vertical launch facility 39 AMR, were developed and transmitted to NASA.

The first issue of the integrated systems checkout requirements for boilerplate 6 was released.

The interface between the command module RCS engine nozzle extension and the Avco Corporation ablative material is being investigated.

Block diagrams showing the spacecraft prelaunch automatic checkout equipment (SPACE) concept were developed and released, a FORTRAN program for umbilical lists has been developed, and a program for the machine-processing of integrated checkout procedures is being prepared.

The MIT requirement that the inertial measurement unit (IMU) of the guidance and navigation system be maintained at 125° ± 1°F was investigated.

An analysis was made of six methods for simulating Apollo systems for the Apollo guidance computer during integrated systems checkouts. Results indicate that five methods are in a reasonable cost-versus-effectiveness band.

TEST INTEGRATION

Detailed requirements for an operational pitch-control motor system, GSE, IFTS, displays, and spacecraft prelaunch automatic checkout equipment have been compiled and listed by computer program. Detailed lists have been published for boilerplates 6 and 12, airframes 001 and 009, and test fixture 2.

Revisions for the quarterly publication of the General Test Plan, incorporating most of the comments made by NASA, and involving a complete format change from a single-volume to a three-volume publication were completed.

MATERIALS AND PRODUCIBILITY

Leak Detection

An investigation concerning the various methods of leak direction applicable to the testing of structural components, final assemblies, and post launch of the command module was initiated.

Meteoroid Test Program

Arrangements were made to subject bare and coated molybdenum specimens to simulated meteoroid impingement at the in-house hypervelocity particle facility. These tests are intended to simulate the effects of impacts caused by minute meteoroid particles.

Refractory Metal Castings

A back-up test program for the selected RCS nozzle coating has been written. It calls for the selection and preliminary screening of candidate alternate coatings for the RCS nozzles.

Fillet-Weld Test Program

To obtain design deformation for fillet-welds, a limited test program has been written to meet the Apollo design requirement. The material involved is 5456 aluminum alloy. Welds will be tested at room temperature only. Details on two fillet sizes and three filler alloys are being sought.

In another limited test program, a study is being made to compare the strength of one- and two-pass welds in 2014-T6 forgings. The initial information on the two-pass weld is favorable.

Material Properties

A request for data on cryogenic properties of the extra-low interstitial compositions of titanium alloys, Ti-5AL-2.5 Sn, and Ti-6AL-4V, was received. A test program is being outlined to obtain the required data.

HONEYCOMB SANDWICH FASTENER

A search is under way to locate lightweight fasteners for honeycomb paneling applications on the service module, and a study to evaluate three promising products is beginning.

PRESSURE DISTRIBUTIONS

External pressure distributions for the tapered lunar excursion module adapter were formally released.

Release of external pressures on the entry face of the heat shield were completed for a command module weighing 9250 pounds with a 15-g entry trajectory.

Incremental external air pressures on the service module RCS fairings have been formally issued. C-1 adapter external pressures are now being investigated.

LOAD AND CRITERIA

C-1 and C-5 boost loads for the spacecraft, using a 155-inch service module and a 116-inch adapter, have been computed and issued. The loads

due to lateral and axial twangs following release from the launch pad have been verified for a step input load.

LANDING IMPACT ANALYSIS

A digital computer program for calculating landing stability and loads of the heat-shield and the command module couch system was successful. Results show a 5-degree negative-pitch attitude is preferable for earth landing.

The analysis of landing on a concrete surface was completed for instances of both rigid and flexible heat shields. A study to calculate the effects of landing in sand has begun. A comparison with the quarter-scale model drop test results will be made.

SHOCK, VIBRATION, AND ACOUSTICS

The airborne tape recorder for boilerplate 12 was tested to determine its ability to survive during earth impact. It was concluded that the recorder should be able to survive all earth impact conditions likely to be encountered.

Body Loads

Modes during burnout are being rerun to determine if modal frequencies occur between 89-141 radians per second.

The effects of launch pad and nozzle support structural flexibility on lift-off and burn-out axial loads are being determined by variable-input program.

A body-loads evaluation for the lunar excursion module adapter is in progress.

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SYSTEM DYNAMICS

WIND TUNNEL PROGRAM

Tests

The 0.105-scale FS-2 component loads model was tested in the Ames unitary plan wind tunnel. Escape motor alone, command module alone, and total lunar excursion vehicle forces were recorded at Mach numbers from 0.7 to 3.4. The effect of the lunar excursion vehicle flow separator was determined.

The FS-3 model was tested in Arnold Engineering Development Center tunnel B to obtain command module stability at Mach number 8.0.

Tower impingement tests were conducted on a 0.085-scale nozzle and a tower quarter section.

Static pressure distribution tests were conducted on a 0.055-scale PSTL-1 model of the Saturn C-1 launch configuration.

A hypersonic (Mach number 7.25) investigation was conducted to determine the effect on the lift-to-drag ratio of nine command module configurations.

PS-3 and FS-3 models were tested in the Arnold Engineering Development Center tunnel C to obtain pressure distributions and force data at Mach number 10.0.

During the next report period, the first drogue chute tests will be conducted in the S&ID subsonic L tunnel. The drogue chute and dynamic stability characteristics of the command module and drogue combination will be determined.

The structural and aerodynamic damping characteristics for an SD-1 model of the Saturn-Apollo block-II launch configuration will be determined in tests in the Langley 16-foot transonic dynamics tunnel.

The first heat transfer tests of the command module in a Hotshot impulse tunnel will be conducted in tunnel F at the Arnold Engineering Development Center during the next report period. The nominal Mach number for these tests will be 19.0.

Initial tests of the 0.085-scale launch escape vehicle jet-effects model will be completed. Data will be obtained over the Mach number range from 0.7 to 1.2.

Model Design and Construction

Modifications to the 0.045-scale PS-3 model were completed so that it can be tested in the S&ID trisonic wind tunnel where pressure distributions on the launch escape vehicle will be obtained through the transonic Mach number range. Rework of the PS-3 model eliminated the necessity of constructing a new model to obtain this data.

A model to investigate jet impingement forces on the launch escape vehicle tower structure was completed. Provisions were included to measure jet thrust and forces on the tower for various amounts of impingement.

The 0.085-scale lunar excursion vehicle H_2O_2 jet effects model was completed and was delivered for installation in the Langley 16-foot transonic tunnel.

Modification of the 0.02-scale FS-1 model was completed. This model is used for investigating the effects of aerodynamic modifications to the command module to improve entry lift-to-drag ratio.

Design was initiated on models for the drogue chute wind tunnel program.

Efforts to reduce the mechanical damping in the support system of the SD-1 structural dynamics model of the Saturn-Apollo boost configuration continued with evaluation of a modified leaf spring support. The model rolled 90 degrees and showed no significant reduction in mechanical damping; therefore, this system was abandoned. Efforts are directed toward modifying the original torque bar system and redesigning the pulley and cable network.

FLIGHT DYNAMICS

A six-degree-of-freedom docking simulation study has been initiated. The view from the command module window during docking is simulated by projecting pictures of a scale model of the lunar excursion module photographed with a TV camera having six degrees of freedom. Design

requirements being investigated include the service module reaction control system (RCS) thrust level, propellant requirements during docking, rotational and translational command modes, automatic control system mechanization, jet select logic, pilot displays, allowable initial docking conditions, visibility and visual cues, target illumination, and target background. Duplicate runs (with different pilots) are being made in sufficient numbers to establish statistical distributions to increase the validity of the data for design purposes.

Use of 25-pound service module RCS jets for roll control during service propulsion system thrusting was investigated and found to be feasible. The thrust level required for docking is under investigation.

The technique tentatively established for separating the command module and service module from lower stages during an abort consists of firing four 2000-pound-thrust posigrade rockets mounted on the service module adapter. With this technique, no retro rockets would be required on the S-IV or the S-IVB. Normal separation from the S-IVB will be accomplished with the service module RCS.

Maximum accelerations that might occur to occupants during launch escape system (LES) abort with tumbling have been determined for human factors analysis.

A study of the effect of jet plume impingement on the LES tower resulted in modification of the tower to prevent impingement below 30,000 feet altitude.

Analysis of Little Joe II trajectory requirements for LES tests was initiated; the effects of such factors as thrust vector alignment and center-of-gravity travel are being investigated.

Present entry propellant requirements are 100 pounds per system. This figure is based on results of six-degree-of-freedom analog computer studies and, as such, is dependent upon the physical realism of the simulation. The following factors and criteria will affect this preliminary figure:

1. Simulated missions were manually controlled to within 50 nautical miles from a selected landing site on a spherical nonrotating earth.

2. Component tolerances, instrument dynamics, and motor thrust transient response characteristics were not considered.

3. During entry the vehicle is not subject to atmospheric variation, winds, or changes in aerodynamic coefficients.

4. Maximum entry range is 5000 nautical miles.

Studies are now in progress to determine the optimum command module control system logic and the reaction motor location. These studies will include realistic thrust transient characteristics and instrument dynamics. Concurrently, the six-degree-of-freedom simulation is being remechanized to include updated nonlinear aerodynamics and primary system end-point steering logic.

Wind tunnel testing of the drogue parachute will be accomplished in the Langley 16-foot dynamics tunnel and in the NAAL facility. Studies to validate the selection of the pertinent parachute parameters and to determine the effect of attachment geometry are scheduled.

An analytical study has been initiated to investigate the effects of attach-point geometry, variation of parachute system parameters, and flight conditions on drogue parachute/command module stability. Results indicate the superiority of multiple attach points.

High-altitude abort tumbling conditions have been more fully investigated, and tentative criteria have been established. Elimination of the supersonic and hypersonic apex forward aerodynamic trim point, in conjunction with RCS/SCS rate damping would ensure a tolerable environment for all LES aborts. RCS/SCS rate stabilization, to arrest tumbling of the command module following a high-altitude LES abort, is required to prevent an intolerable tumbling rate build up. Methods of eliminating the forward trim point are being investigated.

During the next report period, the remechanized entry simulation will be used to obtain realistic propellant requirements and motor duty histories for both automatically and manually controlled entry missions.

Requirements and design criteria for service module reaction control system propellant will be updated as additional data becomes available. Midcourse correction capability and navigational sighting duty cycle will be more adequately defined.

The docking simulation will be continued.

Separation dynamics using the posigrade separation configuration will be studied in more detail.

Little Joe II trajectory analysis and configuration evaluation for LES boilerplate testing will be continued.

There will be continued analysis of LES booster separation, including effects of booster fuel slosh.

An investigation of booster explosion intensity and blast wave propagation will be initiated to aid in LES reliability studies to be conducted later.

A further evaluation of the command module flight following LES abort will be conducted using updated subsonic aerodynamic data.

Studies of automatic command module reorientation by use of accelerometer logic will continue. Alternate apex cover jettison schemes will be evaluated.

Analytical studies to determine the effect of parachute parameters and attachment geometry on command module stability will be made using the recovery system digital computer program.

PERFORMANCE AND TRAJECTORIES

Booster Analysis

An analysis indicated that the C-1B orbital payload can be increased approximately 5 percent by using the service module for earth orbit injection. However, use of this technique will mean that the lunar excursion module cannot be carried because of its position below the service module during boost.

The optimum trajectory required to effect lunar approach orbit injection from a free-return circumlunar trajectory was investigated for an 80-nautical-mile orbit. It was found that the optimum steering maneuver providing maximum payload in orbit requires a characteristic velocity of 3115 fps. By comparison, a gravity turn maneuver starting from the same energy trajectory requires approximately 7 fps more characteristic velocity than the optimum steering maneuver. The total range angle for injection is 20.5 degrees, and the inertial spacecraft orientation changes less than 0.10 degree during the maneuver.

The weight and performance tradeoffs have been determined for the following lunar landing mission variables: gross weight; adapter, burnout, and lunar excursion module weights; velocity increment for command module plus lunar excursion module; velocity increment for command module alone;

percent velocity margin; and specific impulse. Formulae describing the partial derivatives of one variable with respect to another were defined.

The payload capability of the three-stage Saturn C-5 for boost to translunar injection via a 100-nautical-mile orbit was determined using MSFC weights. A net injected payload approximately 1.2 percent lower than the comparable MSFC value was obtained because of the use of a heavier launch escape system and a shorter translunar transit time.

Launch escape system separation performance trade factors $\left(\frac{\Delta \text{ Payload}}{\Delta \text{ Separation time}}\right)$ are -2.8 pounds per second for the C-1 with the service module and -3.4 pounds per second for the three-stage C-5 vehicles where Δ separation time is based on the time elapsed from nominal separation time. The current criteria used to determine payload is based on separation of the launch escape system 20 seconds after second-stage ignition.

During the next report period, an analysis will be conducted to determine the flight parameter dispersions associated with the C-1, the C-1 with the service module, the C-1B, the two-stage C-5, and the three-stage C-5. Combined deviations in thrust, specific impulse, drag, and usable propellant will be used to determine these trajectory envelopes.

The aerodynamic loads trajectory analysis of the Saturn-Apollo launch vehicles will be completed during this period.

A study will be initiated to determine the payload tradeoffs associated with dog-legging during boost into a fixed inertial plane to satisfy launch delays. This technique will be used with launch azimuth variations to vary the inertial transfer plane, which may have the advantage of reducing GOSS and abort recovery areas.

Trajectories are being computed to determine the earliest point on the suborbital C-5 boost trajectory from which there is an abort capability that will allow the command module and service module to attain earth orbit.

Performance Criteria

The effect of translunar navigation sampling frequency on lunar orbit controllability was determined for the first half of a circumlunar trajectory with outbound and return inclinations of 0 degree with respect to the lunar orbital plane. The translunar injection errors for the Saturn ST-124 stabilized platform and a coast arc of 720 degrees were assumed, and two midcourse corrections were made at the optimum time (minimum ΔV) for

each sampling rate. Execution tolerances were 0.1 degree in pointing accuracy, 0.2 second in cutoff time, and 1 part in 10,000 for the accelerometer scale factor. The rms sextant accuracy was 10 arc seconds. The extreme 3σ orbit altitude deviations were 45 nautical miles for a 12-hour interval between observations, 38 nautical miles for an 8-hour sampling period, 20 nautical miles for a 2-hour interval between samples, 15 nautical miles for 1 sample per hour, and 10 nautical miles for 2 samples per hour. The maximum deviations in each case occurred at coast angles of 90 and 270 degrees from the injection point.

Estimates of the effect of platform tolerances and launch site uncertainties on burn-out errors for a lunar excursion module ascent trajectory have been determined. The rms uncertainties were about 400 feet in each position coordinate and 2.5 feet per second in each velocity coordinate.

The influence of random performance factors upon translunar injection errors for the current mission concept using MSFC hardware has been investigated with two possible alternate modes employing the MIT platform and the MSFC ST-124 platform for ascent combined with the MIT inertial measurement unit (IMU) for injection.

Both the single and multiple transearth and translunar corrective maneuvers have been analyzed to some extent, and fuel economy optimization has been considered. This was done from the viewpoint of location of correction points, considering the total cost of removing predicted error components and post-arrival residuals. When two or more maneuvers are scheduled, it is possible to permutate the sequences in which target dispersions are corrected. For example, a first transearth impulse might correct altitude and cross plane velocity errors, while a second could remove errors in time and lateral position. It is planned to analyze the implications of the permutation during the next report period.

The largest acceptable midcourse errors that do not exceed acceptable arrival deviations will be determined. This will provide a means of evaluating the mission reliability gains resulting from deletion of in-flight engine restarts.

A planned study will extend guidance-performance interface studies to consider the effect of making navigational sightings with a nonuniform sampling rate.

It is planned to associate real stars and other ephemeris data with the results of previous navigation studies.

Entry Analysis

A preliminary analysis of the atmospheric entry of the service module was made to provide trajectories for an investigation of heating and break-up. Service module trajectories were provided based upon command module entry conditions for overshoot, normal entries, and 10-g undershoot.

Control modifications and additional terms included in the S&ID Knott's atmospheric terminal steering system (KATS) improve the range prediction accuracy and result in decreases in touchdown position errors. One modification yields an improved range prediction solution at the high velocity end of the subcircular region by accounting for path angle variations from equilibrium; another improves the steering control within a range-to-go value of approximately 100 nautical miles. The latter change is to reduce the terminal errors (drogue deployment altitude) from approximately 20 to less than 5 nautical miles.

A preliminary analysis of suborbital abort from a nominal C-1 boost trajectory from AMR indicated possible impact on land. With a command module lift-to-drag ratio of 0.5, an abort during an 8-second period in the boost trajectory would result in an impact on land. If a lift-to-drag ratio of 0.35 was used, the period would be 12 seconds. The critical abort period is maximum for launch azimuths from 75 to 85 degrees and diminishes to zero at an azimuth of 90 degrees.

During the next report period, a development program of survival guidance concepts and systems design criteria for atmospheric entry from lunar missions will be formulated.

Preliminary trajectory constraints during the entry flight phase from lunar missions will be determined. These constraints define the path limits required to avoid supercircular exits and excessive loads throughout the flight regime.

A three-dimensional analytical method for determining the minimum energy ejection requirements from earth orbits for specified ranges will be completed.

Maneuver loads during entry, recovery envelopes, and preliminary landing site requirements will be determined for aborted missions during exoatmospheric boost. The effects of aborting the mission with the service module as well as the S-IV will be included.

Guidance sensing uncertainties and heating characteristics will be compared with entry trajectories using KATS and trajectories determined for heat shield design.

Space Operations

A lighting wheel analogue has been developed that allows a qualitative estimate of those times of any month for which various lighting restrictions at earth launch, translunar injection, lunar landing, transearth injection, entry, and landing can be satisfied. The lighting wheel will allow the simultaneous evaluation of lighting conditions at the trajectory events as a function of time of month, month, and year for both earth launch windows.

A circumlunar error sensitivity analysis has been completed for four representative free-return circumlunar trajectories. The variations in translunar and earth perigee radii were determined as a function of perturbations in translunar injection conditions.

The development of the Encke Precision Lunar Trajectory program is almost completed. In addition to the very efficient Encke problem formulation and a fast Adams-Moulton numerical integration scheme, the new program features the following: an oblate earth (second, third, and fourth harmonics), a plus-in atmosphere about earth (presently ARDC 1959), a triaxial moon, an ephemeris providing position and velocity data for the celestial bodies, a computational scheme performing selenographic and precession/mutation coordinate transformations, a multiple tracking station capability, and an ability to stop on a multitude of variables (up to 14) dictated by input and to perform subsequent maneuvers (up to 15). Present capability permits studies of circumlunar free-return trajectories as well as earth (or moon) orbital decay time histories as affected by oblateness and drag (or triaxility and outside body) effects.

THERMAL ANALYSIS

Aerothermodynamics

The maximum heating rate calculated on the launch escape system (LES) tower caused by rocket plume impingement for abort at 5000, 50,000, and 80,000 feet was 360 Btu square feet per second.

Heating rates on the command module radome caused by LES plume impingement indicate a maximum heating rate of 103 Btu square feet per second occurring at an altitude of 100,000 feet.

The command module pressure distribution profile for the launch phase under conditions of LES shock impingement has been estimated for Mach numbers 7 through 9, and maximum pressure rise coefficients come within ±10 percent of Jet Propulsion Laboratory test results.

Heating rates and distributions for the first 10 aero-heating tests of the command module reaction control system rocket nozzles have been obtained.

The test model (HL-1) used in the Arnold test will be modified for use in the Langley test to obtain heat transfer measurements on the LES tower.

During the next report period, the entry heating program will be improved.

Calculations that will be determined for each body point are Reynolds number, shear stress, pressure, temperature, and laminar-turbulent flow indications.

The analytical correlation of experimental data will be extended to the afterbody during entry and to the launch configuration during boost using Arnold Engineering Development Center and Jet Propulsion Laboratory data.

Command-module reaction control system (RCS) entry heating test data will be correlated with theory.

Shock surface definitions will be extended over the entry face on the vertical and horizontal planes beyond the current definition.

The discrepancy between the Boison and Curtiss cut-sphere effect on heat transfer and Apollo test results will be resolved.

The second half of the command module RCS rocket entry heating program will be completed.

Entry heating tests will be performed on the 0.04-scale model of the command module in the Cornell Aeronautical Laboratory shock tunnel.

Space Heat Transfer

Command Module

Under these conditions, the structure must be designed to withstand a temperature of -290 F, or some method of orienting or heating the vehicle must be provided to alleviate the low temperature. An investigation based on a two-dimensional transient analysis that considers conduction directly into and circumferentially around the command module surface is proceeding.

The temperature distribution on the surface of the service module caused by impingement heating from a 60-second maximum burning period of the 100-pound thrust reaction control system engines were determined.

With the reaction control system 8.25 inches from the surface of the service module and with the axial and roll nozzles canted 10 degrees, 97-pound insulation is required with the RCS located at station 325.

During the next report period, plume heating effects on the antenna will be determined for the service module RCS.

The three-dimensional thermal analysis of the service module will be completed.

Requirements will be determined for the main engine fuel line heater located inside the service module.

Insulation evaluation tests will be analyzed and conducted.

Main engine heating of the service module aft bulkhead will be analyzed.

A temperature analysis of the glycol loop line in the service module will be prepared.

Atmospheric Heat Transfer Analysis

Launch Escape System

A preliminary investigation of the instrumentation (accelerometers and amplifiers) used on the LES boilerplate 6 and 12 for the pad abort condition indicates that the maximum expected temperature is 120 F.

During the next report period, weight tradeoff studies of the LES tower will be conducted.

Boilerplate temperature profiles and insulation requirements will be determined.

Command Module

The ablation material test program is testing specimens for high-enthalpy (25,000 British thermal units per pound) in a plasma-jet facility. These tests will provide empirical design data for immediate use based on gross ablator performance of the specimens.

A study of the problems associated with pressure differentials across the command module outer structure during boost, tumbling abort, and reentry has determined that a vent area of 3 square inches, which can be formed by opening a window cover, is sufficient to reduce the pressure differential across the structure during boost. No venting is necessary during

the heating phase of reentry. This permits safe venting by opening a leeward duct at altitudes below 100,000 feet (the phase in which the pressure differential becomes significant). Penetration of the aft heat shield for alleviation of the structural pressure differential during an α = 180 degree tumbling abort is not feasible (sonic shocking at the duct inlet would prevent adequate pressure equalization. Therefore, the aft heat shield structure should be designed to withstand a differential of at least 12 psi).

A study of the command module quartz window from boost to abort at an altitude of 200,000 feet followed by 11 seconds of random tumbling indicates that the quartz window may heat to 2500 F with the window cover removed prior to launch or 1800 F with the window cover removed at the time of launch escape system tower jettison.

During the next report period, temperature histories will be made of the command module aft compartment frame bolts.

Temperature histories will be made of the command module shock attenuation fittings.

Thermal protection requirements will be determined for the command module tower wells.

Cabin temperatures during an abort condition will be analyzed.

Heat shield tie-down bolt thermal design requirements will be determined.

Arc jet tests will be conducted to determine the effects of entry heating on the umbilicals.

Heat shield monitoring will be performed.

Temperature histories will be made of the observation windows during entry and boost abort.

ENVIRONMENTAL AND POWER ANALYSIS

Environmental Control

A study of reentry temperatures was completed. Without additional cooling, suit inlet temperatures are expected to increase from 50 F at 100,000 feet to 90 F at parachute deployment. The average inner wall temperature is not expected to exceed 75 F at parachute deployment and 95 F on landing. After landing, the inner wall temperature may be expected to rise approaching 150 F.

The suit circuit computer program used for analysis and evaluation of the performance was updated to include latest component performance data and more complete fan map data including individual water and oxygen flow rates. This allows for the determination of the condition of the air at pertinent points throughout the system.

Computer runs to determine the supplementary cooling water usage rates and radiator areas have been completed using the environmental control system (ECS) water-glycol circuit.

During the next report period, the pressure suit circuit computer program will be revised by incorporating more detailed fan performance data, minor changes to agree with the latest AiResearch schematic drawing, and new component pressure drop characteristics.

Cabin and suit loop conditions during reentry will be redefined based on a revised suit loop, revised cabin heat loads, and new data on inflow air temperatures.

Crew Support

The water management computer program, used to evaluate the performance of this system, was modified to include provisions for a cathode ray tube and direct print-out.

During the next report period, the analysis of the water management time history will be revised to include changes in the water available from the fuel cells, revised sweat and urine rates, backpack requirements, and revised mission times.

Unmanned Spacecraft

A preliminary analysis based on new data and NASA ground rules indicates that no on-board ECS is required for boilerplate 6, provided that (1) a flat white paint is used on the exterior surface, (2) skin temperatures do not exceed 250 F, (3) no insulation or ablation material is used during launch escape system (LES) firing, and (4) that launch is made before 1000 hours.

During the next report period, boilerplates 6 and 12 will be analyzed to determine the best method of absorbing the heat output from the coldplate cooled instrumentation.

Boilerplate 13 will be analyzed in accordance with new NASA ground rules and heat load data to determine ECS requirements.

Equipment Cooling

Analysis of several coldplate designs were completed, and minor changes were recommended.

Heat transfer tests have been conducted using a Collins simulated electronics module and an instrumented honeycomb coldplate. Test data analyzed so far indicate that interface conductance is lower than expected.

During the next report period, the coldplate designs will be analyzed to determine thermal characteristics.

An analysis will be made of the capability of using structure as an equipment heat sink. An analysis being made of the lighting heat sink requirements for the command module will continue as one part of this program.

Honeycomb sandwich construction plates will be tested to determine effects on plate surface temperatures of intersurface heat transfer at various conditions of heat loading.

Radiation Protection

A set of time-dependent differential energy spectra for four solar proton events has been developed with data obtained from the NASA proton event manual. Curves for dose rate and dose compared with time (for 153-region spacecraft geometry) were computed for these events.

The dose at a point inside the command module for the NASA model event and the 153-region geometry was 1700 rads.

An error analysis of the radiation dose program was completed. The analysis shows error in dose as a function of error in range energy equation, number of terms in the dose integration equation, and size of energy increment in integration.

Shielding system studies and plans for shielding verification studies have been continuing.

Power Systems

Thermodynamic control functions for the primary loop during steady-state operation have been derived by use of fuel cell performance data.

The analyses for three cases of GSE prelaunch heat rejection have been completed. Analyses of rapid cooldown for replacement of a malfunctioning fuel cell during ground checkout have been completed.

SPACE RADIATORS

The analysis of optimum radiator area requirements for various phases of the Apollo mission was completed.

The resizing of the electrical power systems (EPS) radiator was completed for the new heat loads. Results indicated 11.5 square feet of effective radiator area per fuel cell module is sufficient for all normal operating conditions during the present mission profile.

Studies of the radiator surface and supplementary cooling requirements were also completed for a vehicle drifting at random in transit and in lunar orbit. Both area control and supplementary cooling are required for lunar orbit if the random orientation is used because the random flight mode implies possible operation in the severest environment during each mission phase.

During the next report period, effects of revised radiator surface properties (α = 0.15, α = 0.92) on the EPS radiator performance will be investigated.

The ECS radiator will be analyzed for on-off control conditions of shared circuits and for flow rates of glycol through circuits on opposite sides of the service module.

Preliminary radiator test performance criteria will be written.

Screening and evaluation of radiator surface coating samples will be completed.

The EPS and ECS radiators will be analyzed for transient conditions.

Analyses of gas heating processes and modes will continue. Particular emphasis will be placed on passive methods (concerning internal-heating spheres) and dynamic approaches (fans and pulsating chambers).

An analysis and evaluation will be performed of superinsulation requirements (heat leak in compressed and relaxed states).

The investigation of heat leaks through fill-and-vent lines will continue.

Gas temperature profiles (delivery to ECS and EPS through a transient-heat transfer analysis) will be determined.

The optical properties are being measured before and after simulated solar exposure equivalent to 300 sun-hours. The material tentatively selected is Armour Research Foundation coating 441-2. It is included in the eight samples provided to Ames Research Laboratory for test on the S-17 orbiting solar observatory.

PROPULSION ANALYSIS

Propellant Systems

Propellant Utilization

An analysis at limiting conditions has shown that a propellant utilization valve in the service propulsion system (SPS) can save approximately 400 pounds of propellant and can simplify manufacture, checkout, and loading procedures.

Fuel

Various data relating to the physical properties of monomethylhydrazine and to theoretical performance data of monomethylhydrazine and nitrogen tetroxide have been obtained because of the decision to use monomethylhydrazine as fuel for the command module RCS. Monomethylhydrazine has a lower freezing point (-67 F) than does nitrogen tetroxide (12 F).

Boiloff of nitrous oxide in mixed oxides on nitrogen may be a problem when it is used as an oxidizer.

Computer Program

The second status report of the propellant systems analog simulation program was completed. Effort is continuing in the areas of tankage and propellant line pressure transients. Emphasis is being placed on propellant line pressure transients because of high-surge pressures that may be encountered and because these pressure transients are so important in describing the operation and performance of the pulsing RCS engines. Current work concerns introducing friction losses into the basic water hammer equations.

Tank pressure and fluid dynamic trade-offs will be evaluated for the series and parallel-feed SPS tanks of the service module.

Tests will be conducted to determine the solubility of helium in the propellants and to verify data on other propellant properties.

Effects on the propellant system performance of the service module RCS as a result of the change to monomethylhydrazine fuel will be determined.

Ground Support Equipment

The minimum volume needed by the GSE helium storage bottle that services the command module and service module helium system has been calculated and sized at 80 cubic feet with a pressure of 10,000 psia.

Heat exchanger requirements for the helium servicing systems for the 10,000 psi storage system also have been completed.

Engine Analysis

Command module RCS engine performance data using monomethylhydrazine and nitrogen tetroxide were established on an incremental basis as a function of chamber pressure and nozzle expansion ratio for both frozen and equilibrium flow conditions.

A survey of available solid propellant motors for use in posigrade to separate the service module and the S-IV stage was completed. A Prima I rocket motor appears to satisfy the requirements of 2000-pound thrust for 2 seconds.

Calculations (100- and 25-pound thrust) of the service module RCS plume impingement properties of distributions longitudinally and circumferentially along the service module were completed.

Flow field values were determined for nozzle center line-to-surface distances of 3, 6, and 12 inches with cant angles of 15 to 25 degrees. Off-centerline distributions on the surface were also determined for these cases.

Checkout of an IBM computer program on the plume is progressing.

Constant engine mixture ratio under failure and nonfailure conditions will be obtained by using orifices at the main engine propellant control valves. Additional inlet pressure may be required to provide sufficient pressure drop across the calibration orifice.

During the next report period, a heating analysis of engine nozzle radiation and thrust chamber heating of the aft bulkhead and SPS engine components of the service module, including gimbal and gimbal actuators, will be completed.

The parametric propulsion system analysis of the command module RCS will be completed.

The analysis of posigrade rocket motor characteristics will be continued, and the effects of a thrusting S-IV during abort separation will be evaluated.

The analysis of effects of meteoroid impingement on the service module RCS engines will be continued.

Initial investigations of the LES motor thrust-vector variation resulting from axisymmetric nozzle erosion will be completed.

An analysis of leakage in the RCS engine valves will be initiated, and the effects on system performance will be evaluated.

AERODYNAMICS

Analysis and Criteria

Estimates of the hypersonic aerodynamic characteristics of the service module including the hypersonic characteristics after separation were completed. Estimated aerodynamic coefficients for the command module-with-service module configuration were completed also.

Command module configuration studies will be continued to determine the possible design modifications which would be required to restore entry lift/drag capability and to eliminate apex forward trim.

Analysis reports will be published of the results of wind tunnel tests for measuring the static stability of the command module and launch escape vehicle over the Mach number range from 0. 70 to 3. 5.

An approximate analysis will be started of the separated flow region behind the command module to obtain the properties within this region, its configuration, and of the bounding shear layer.

Criteria as to whether the flow is frozen or in equilibrium will be analyzed. These criteria will eventually be incorporated into a flow field analysis to provide a first cut at the nonequilibrium flow field.

The flow field on the top and bottom sides of the command module at angle-of-attack will be defined for various points along the entry trajectory.

Drogue Chute Deployment

The feasibility of signaling for drogue deployment by pressure monitoring on the command module surface was examined. Entry and abort trajectories, including the possibility of apex-forward trim or command module tumbling for the latter case, were analyzed. Preliminary results indicate the command module surface pressure in the region aft of the apex is practically a lone function of the free-stream static pressure (and consequently altitude) for heat shield-forward flight.

Reaction Control System

A method for calculating the local pressure, density, and Mach number distribution by a rocket exhaust impinging on a surface has been completed. The method is valid in the region where the exhaust plume intercepts the surface.

Lift-To-Drag Ratio

Wind tunnel test results are being evaluated for various aerodynamic fixes to retrim the command module at the proper lift-to-drag ratio. The four basic modifications employed are heat shield cant, heat shield cant plus lateral translation, external flaps, and heat shield blunting.

CONFIDENTIAL

STABILIZATION AND CONTROL SUBSYSTEM

DESIGN

As a result of equipment in the lower equipment bay being relocated for center of gravity correction, the electronics control and display electronics packages have been rearranged to occupy four cells, and the body-mounted attitude gyro package, rate gyro package, accelerometer package, and their related electronics will be mounted on the prime structure directly to the left of the inertial measurement unit (IMU) and will occupy a space approximately 8 by 15 by 12 inches. All electronics for these three packages will be redundant with in-flight maintenance of the body-mounted attitude gyro package rate gyros only.

All work has been stopped on the horizon and sun sensors.

Checkout requirements for the stabilization and control system were established for the spacecraft prelaunch automatic checkout equipment concept, and a measurement list was compiled.

GROUND SUPPORT EQUIPMENT

Minneapolis-Honeywell submitted a list of signals that are to be brought through the umbilical connector to the ground support equipment. The submittal also included the number of wires to the reaction jets and engine controls. This information was used to update an umbilical and feedthrough list.

PROPULSION INTERFACE

The design and functional development of a single-coil solenoid valve driver is complete. Two service module reaction jet solenoid valves have been received from the manufacturer, and a fluid test bench is almost completed. Evaluation tests will start next month.

Work will start on the preliminary design of the test rig for the service propulsion engine thrust vector control servoactuators.

STABILIZATION AND CONTROL SYSTEM REQUIREMENTS

The elimination of the boilerplate stabilization and control system, prototype horizon sensors, sun sensor, and Euler angle generator affected the progress of the functional stabilization and control system block diagrams and the mission criteria specifications for boilerplate B-22 and airframes 009, 010, and 011.

During the next period, the latest configuration of the stabilization and control system (SCS) functional block diagram will be completed. Stabilization and control system mission criteria specifications will be completed for all applicable boilerplate and airframe vehicles, and final installation requirements for all stabilization and control system equipment will be determined.

SUBCONTRACTOR ACTIVITY - MINNEAPOLIS-HONEYWELL

Minneapolis-Honeywell was directed to prepare a new work statement and cost proposal in line with the limitations of the revised program directives outlined in the new hardware utilization lists.

The SCS procurement specification will be revised during the next period.

Final package sizes for SCS equipment will be coordinated with Minneapolis-Honeywell, and review of the Minneapolis-Honeywell documents will be completed.

FACILITIES

The laboratory has been moved to a larger and more appropriate location. The recently received SCS components will be tested when the new area has been equipped.

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CREW PROVISIONS

HUMAN ENGINEERING

Crew Equipment

The illumination operation study for evaluator 5 has been completed.

Design criteria and requirements will be established for the following items:

Window filters for the command module

Interior floodlights for the command module

Interior integral lighting for the command module

Portable light for the command module

Exterior lighting for the command module

Design configurations for the toggle, rotary, push-button, and thumbwheel controls to be used in the command module

Design configuration for the displays to be used in the command module

Evaluators and mock-ups will be revised to conform with the latest configuration.

Personal Equipment Requirements

The pressure chamber for the space suit arm simulator was tested. Testing was stopped at 2.7 psi differential because of cracks and deflections in the plexiglass. Redesign of the transparent panels will be necessary.

A study of partial body radiation shielding has been completed and will be included in the Quarterly radiation report.

Several waste systems will be designed and tested for Apollo use during the next report period.

Several drinking devices will be designed and tested.

Work will be conducted on establishment of anthropometric dimensional criteria for astronaut selection.

A mock-up of the partial body radiation shield will be evaluated.

Crew restraint system concepts will be evaluated.

A radiation shield mock-up will be completed during the next report period.

Spacecraft Design Support

Test procedures were determined for the preliminary postflight ventilation test to be conducted in boilerplate 1.

Human engineering design data for the space suit and cabin umbilical connectors was released.

A preliminary evaluation of a crew evacuation system was completed.

Design criteria for extravehicular operations will be prepared during the next report period.

Management tasks of the command module reaction control system (RCS) will be defined.

Tasks will be defined for normal management of the environmental control system (ECS); failure modes will be identified, and display requirements will be ascertained.

The philosophy and detail design evaluations of manual controls including size, configuration, and actuation forces will be initiated.

Ground Control and Support

Efforts to determine the optimum display and control locations for GSE panels will continue.

Lamp Test Program

The incandescent instrument lamps are being subjected to high and low temperatures in a high vacuum to determine operational characteristics.

Crew Performance and Training

Recommended changes were incorporated in the cost estimate of the visual display study to permit the inclusion of human factors design criteria in the "Statement of Work for Apollo Communications and Data Subsystem".

The first computer run to estimate crew work loads for a 2-hour segment of the lunar mission was accomplished.

IFTS capability and GOSS interface demonstrate the implications of crew dependence on GOSS information as the source of malfunction data during mission.

A report on human performance in optical sighting tasks is being prepared in connection with an evaluation of MIT's proposed optical navigation equipment. The associated apparatus, procedures, and statistical analysis were defined.

A revision of preliminary failure analysis ECS has been completed.

A new approach that orders error data into subindices for the performance scoring has been outlined for Method I. These scoring categories will be individually tested during the next report period to determine their role in the indexing of training error sequences.

Studies will begin on the 6.1 Phase-II Program. Results will be analyzed for use on the manual modes.

Work will begin on obtaining requirements for incorporation into the 6.3 Phase-I Rendezvous Study.

An evaluation of the proposed sextant design will be evaluated in terms of human perceptual error.

An analysis of the earth landing system (ELS) will be undertaken in terms of in-flight maintenance capabilities, failure analysis, and failure effects.

A revision of the current task analysis will be initiated to incorporate design changes and mission concept changes, including the lunar-excursion module-lunar orbital rendezvous concept. The analysis will cover crew tasks for all missions.

Evaluations will be made of the meteoroid and decompression studies pertinent to the Apollo operations and environmental safety during flight activities.

Biomedical

A material schedule and an authorization list for personal hygiene items were prepared. Medical clearance processing of four subjects has been completed for bailout and egress tests. Thermal analysis of a pressure garment assembly was completed.

A table of equivalents and spacecraft axes as well as terminology for acceleration and displacement vectors were completed.

A statement was made concerning the oxygen consumption of a crew consisting of 50th, 70th, and 90th percentile men.

Data are complete concerning the results of the preliminary minimum body angle test. A preliminary evaluation was made concerning the effects of acceleration on vision.

Test subjects will be medically examined during the next report period.

An instrumentation checkout will be made of the medical monitoring system.

Operations and Safety

Safety aspects concerning ground handling and transportation of the command module were defined.

A preliminary control switch evaluation study was completed. Thirteen types of switches have been rated on a feasibility scale. Preliminary criteria were developed for control switch standardization.

An aerospace safety analysis of crew escape will be completed during the next report period.

Visual aid and crew control techniques will be developed for the command module-lunar excursion module docking and coupling.

A system will be initiated for programming astronaut operational inputs with NASA crew systems.

The current control display environment will be reviewed, and an operational evaluation will be conducted.

SIMULATION AND TEST

A procedure for selecting subjects for manned simulation tests is complete.

Results of the 20 bailout and emergency egress tests conducted in evaluator 1 are presented in Table 1.

Table 1. Emergency Egress Test

Number of Tests	Test Condition	Average Egress* Times (seconds)
5	Three crew members with full equipment – egress through center hatch	16.0
5	Three crew members with full equipment – egress through blow-out hatch	10.7
5	Three crew members in pressure suits without parachute and survival pack – egress through center hatch	6.5
5	Three crew members in pressure suits without parachute and survival pack – egress through blow-out hatch	3.5

* Egress times will be evaluated from the motion picture coverage.

Pressure suit donning and doffing tests were conducted to evaluate the spatial provisions within the command module. Two subjects assisted each other in overcoming difficulties encountered with the zipper across the back, in securing the helmet neck ring, and in sealing gloves at the cuff. Results are given in the following listing.

Subject	Mean Time to Don (Min:Sec)	Mean Time to Doff (Min:Sec)
1	5:09	2:07
2	4:45	2:17

The instrumentation system for obtaining impact acceleration data from the drop-test vehicle, boilerplate 1, has been installed. The first water-impact drop test of this vehicle has been monitored.

An investigation was conducted to establish the difficulty level of the problems that will be used in crew performance.

A flight control simulation for Phase-II of the 6.1 study will be performed to determine the crew member's ability to decrease tumbling by using degrees of freedom. Performance will be evaluated with various control and display configurations.

Human engineering evaluation tests will be accomplished on mock-ups 2, 4, 7, 12, and 18 and on evaluator 2.

Requirements and programming will be completed for centrifuge tests, human engineering and design evaluation testing in the house spacecraft (boilerplate 14), and environmental testing in an environmental-proof spacecraft (airframe 008).

Flight control will be simulated in the Apollo lunar excursion module transfer and docking study at NAA's Columbus Division. This study will determine man's ability to control translation and attitude in effecting a safe final phase docking maneuver and the most effective visual arrangements for the pilot in the final phase docking maneuver.

LAUNCH ESCAPE SUBSYSTEM

LAUNCH ESCAPE TOWER

A new tower configuration with an internal structure that will clear the launch escape motor exhaust plume at an altitude of 30,000 feet has been designed and analyzed. Impingement is avoided by slanting the diagonal members in the upper bay towards the interior of the tower and attaching them to a ring.

A study of the effect of secondary bending caused by rigid joints revealed that the bending was negligible and that no significant error resulted from assuming pinned joints.

The tower structure was completely revised to eliminate possible structural weakness caused by exhaust plumes from the launch escape rocket engine. Change drawings were released to manufacturing and tool design for the second tower structure planned for static tests.

The aluminum launch escape tower for mock-up 18 was completed and subsequently used for tool proofing of weld and prefit jigs for the titanium configuration. After these operations were completed, rework was begun on the mock-up tower to incorporate the new design.

During the next period, assembly operations of the dynamic test tower will continue, and fabrication of assembly tooling will be completed to support the development of the initial static test tower.

A temporary subroutine for the truss analysis program will be checked out. Computations for the launch escape tower flexibility coefficients and effective electromagnetic interference curves will also be checked out during the next report period.

The new pitch control motor housing will be analyzed.

Mechanical properties tests of K-design clusters of 6Al-4V titanium alloy will be conducted. The clusters are being welded.

Simulated tower drawings for the escape tower separation test will be released.

FORWARD HEAT SHIELD

Stress check, with an assumed temperature of 1000 F, of hardware involved in carrying the heat shield with the tower on high q aborts has been performed. Load factors applied to the forward heat shield are the condition of 1500 pounds of ballast, thrust on, and system tumbling.

New drawings of the forward heat shield to escape tower latch were released. This redesign was necessitated by a redesign of the tower well on the boilerplate heat shield.

LAUNCH ESCAPE MOTOR

The first motor loaded with inert propellant was delivered.

Preparations were made for the beginning of live motor development static testing.

The design study of alternate exhaust nozzles was terminated because the requirement for alternate nozzles has been deleted.

All process and test tooling, including the multicomponent static test structure, has been dimensionally and functionally checked out.

S&ID and Lockheed Propulsion Company reviewed the structural integrity of the main launch escape rocket motor.

A stress check was made on the escape rocket case in which stresses induced by inertia and airloading were compared with those induced by bearing pressures.

Subcontractor Activity - Lockheed Propulsion Company

The first inert launch escape motor and the first inert pitch control motor were delivered to S&ID on schedule. Testing of propellant batches is proceeding.

During the next report period, processing of live launch escape motors for development static test will begin. Initial sets of nozzles and aft closures will be received.

TOWER JETTISON MOTOR

The inert motor for boilerplate 9 was assembled. Processing of the first batch of live development motors has begun.

Electrical installation details were completed and were incorporated into the interstage drawing.

The tower jettison motor thrust offset angle has been increased from 1.0 degree to 2.5 degrees. Over-all performance and weight of the unit were not affected.

Subcontractor Activity - Thiokol Chemical Company

The first inert motor was received at S&ID during the report period. The first batch of eight development test motors was cast.

Testing of frozen propellant motors continues. Results to date are considered satisfactory.

The tower jettison motor igniter development program will be completed when explosive bridge wire components are received in the next report period.

Live static development testing of the tower jettison motor will begin.

PITCH CONTROL MOTOR

Cases and aft closures are being manufactured from stock materials.

An inert pitch control motor was manufactured, but because of delivery schedule requirements no attempt was made to cast an inert propellant grain into the chamber. Weight and balance features have been simulated by ballasting.

Process tooling for the pitch control motor will be manufactured, and tooling tryouts will be accomplished during the next report period.

TESTS

The installation drawing of the aircraft-to-command module drop test separation system has been released.

Instrumentation requirements for the launch escape subsystem static firing test are being reviewed.

Design of the test jig for the launch escape tower static test has progressed.

Detail drawings are in progress for Apollo Test Requirement 502-2. Detail parts and raw stock have been ordered to support this test.

The pyrogen igniter development testing will be completed during the next report period.

LOADS AND CRITERIA

Launch escape system (LES) loads reflecting the latest weight and abort parameters were completed.

Evaluation of LES loads during jettison after normal boost is in progress. Time histories of the critical loads resulting from the use of the escape rocket during the jettison sequence are being prepared.

Loads between the LES and the command module during jettison of the LES after the start of an abort are being evaluated.

CONFIDENTIAL

ENVIRONMENTAL CONTROL SUBSYSTEM

COOLANT SYSTEM

Water-Glycol System

Glycol-pump testing has shown that the use of a magnetic drive and a dry, two-pole motor, coupled with a Barske-type pump, would exceed the 17 percent over-all design goal efficiency.

Impeller tests on a laboratory dynamometer resulted in the selection of a diffuser of 0.065 inch diameter. This diffuser design is now being tested at temperature extremes of 0 F to 150 F.

To satisfy the need for a water-glycol pump capable of delivering a flow of 0.37 gpm at a pressure rise of 30 psi, an investigation was made of an unshrouded, straight-vane, centrifugal pump powered by a dry motor with a magnetic drive. One water-glycol pump was deleted as a result of the cost program. The recommended water-glycol inhibitor formulation includes etheylene glycol, distilled water, triethanolamine phosphate, and sodium mercapto-benzothiatole.

Although the existing glycol temperature sensor will be used for the prototype model, it will be redesigned for future applications because its over-all size is greater than desired when externally insulated.

Coldplates

Repackaging in the lower equipment bay area to shift the vehicle's center of gravity will require major revisions in most, if not all, of the completed coldplate drawings.

The coldplate testing of the Collins Radio module, using the module as the heater and a glycol-solution-cooled coldplate, will be completed during the next report period. Testing will then begin on laboratory hot-plates and selected interface materials.

Fabrication and testing of adhesive-bonded aluminum coldplates were completed, and two specifications were written on fabrication procedures and process controls.

An evaluation study is under way to determine effects of glycol-water solution on the nitrile-phenolic adhesive systems. Lap shear specimens were fabricated and environmentally exposed.

Space Radiators

Test samples of space radiator core sections withstood 150 psig when subjected to a leak check. Based on present heat dissipation requirements, it was shown that 82 square feet of radiator area is required for Earth orbit and 60 square feet for lunar orbit. A charting of heat loads showed that adequate heat dissipation could be obtained for full-flow rates and total radiator area by using water evaporation as a supplement. The charting also showed that the total water requirement would be within the present production and storage capabilities of the spacecraft.

Provisions for on-pad access to the fuel cells of the electrical power system (EPS) has resulted in a relocation of the environmental control system (ECS) space radiators. This location straddles sextants II and III for one panel, and V and VI for the other panel. A layout is being made of a configuration that will use alternate cooling passages in a single panel. This routing would give an effective total-panel area of either 60 square feet or 82 square feet, depending upon the mission requirements.

During the next period, protective coatings suitable for preventing corrosion in radiator cooling fins will be investigated, and tested.

Cabin Pressure and Temperature Control

Valves of the ECS are modified to meet the new 5.0 psia oxygen operating requirements. The time to repressurize the capsule from 0 to 5 psia is now one hour. All oxygen partial pressure controls are deleted from the system. The pressure differential setting of the cabin pressure relief valve manual control is changed to an isobaric setting. The relief-pressure setting of 7±0.2 psia is changed to 6±0.2 psia.

A light weight, semirigid, polypropylene container is designed to replace lithium hydroxide charges. In addition to the breadboard testing of lithium hydroxide, which demonstrated the adequacies of the canister size and shape, feasibility tests were performed utilizing lithium oxide.

Extensive investigation was begun covering the feasibility of wicking material in the wick-type water separator. A prime objective of this investigation is to determine the effects possible contaminants may have on various wicking materials. Results of this investigation indicate that the contamination problem can be overcome without requiring maintenance in flight.

The inflow and outflow snorkels are replaced with an inflow, cabin-vent valve and an outflow cabin-vent valve. The deletion of the snorkels eliminates the need for the snorkel-attitude test simulator.

NASA's request for a cost reduction program resulted in the following changes:

Elimination of the catalytic burner

Elimination of spare recirculating blower for the cabin

Elimination of the air lock pressurization subsystem

Replacement of the sponge-type water separator with the wick-type

Elimination of one pressure-suit compressor

Oxygen System

Preliminary studies of the effects of exposing lubricants to low-pressure oxygen have established DC33 grease and Versilube F50 oil as acceptable for use in a breathing-oxygen environment up to 150 F. Testing at higher temperature ranges is being conducted. Check valves and relief valves of the reentry oxygen subsystem module are being tested. The tank valves have been received and are ready for welding.

Cryogenic Storage System

The cryogenic storage system schematic is revised to include electric heaters, rather than glycol heat exchangers, for maintaining pressure in the storage tanks. Forged and machined hemispheres will be used for the pressure vessels. The capacitor-type, quantity sensor is deleted from the storage tanks.

As a result of deleting manual override provisions for the cryogenic valves in the service module, a study is being conducted of the effect on reliability apportionment. Layouts are being revised to show the location of the hydrogen storage tanks in sextant I, as well as the relocation of oxygen and hydrogen valves.

Electrical power load estimates show that the elimination of the 50 percent pad, based on the total quantity of metabolic oxygen, could limit mission duration to approximately 12-1/2 days, if one oxygen tank were lost.

WATER MANAGEMENT

Several methods were investigated to gage water quantity in the potable and waste water storage tanks. The pressure differential across an elastic-type bladder was chosen as the simplest and most reliable indication of water quantity. Suitable rubber materials for the bladder and mechanical design of the unit are being studied.

Two materials were selected as suitable for the water management system from the standpoint of compatibility and performance. Studies are now being made to develop tooling and fabrication methods for rubber components.

Currently the electrical, command-to-service-module disconnect blocks the planned tube routing along the outside of the command module wall, so a layout is being made to revise the tube routing in the ECS. The EPS interface for the water line of the ECS will be located at the junction of the three individual water lines which extend from the fuel cells.

A study is being conducted to determine what potential effects the replacement of fuel cells by solar cells would have on the water management system and other parts of the ECS.

The possibility is being considered of dumping water vapor and Freon in the aft equipment bay, with suitable escape holes provided through the outer skin of the command module. Ablation protection for 12 inches upstream is being provided for the exit portion of the 2-inch, vapor vent duct attached permanently to the skin of the command module.

WASTE MANAGEMENT SYSTEM

A backup valve was added to the urine overboard line, downstream of the selector valve, to prevent any possible leakage overboard. A procurement specification for this valve is being prepared. Support brackets for the waste management system components, located in the right hand equipment bay, are being redesigned to accommodate the 5 to 6-inch change in panel width.

Data concerning the connection of the waste management system to the ECS were transmitted to AiResearch. Mounting support information for water tanks was also presented to aid in tank design. Procurement specifications for the selector valve and chemical tank have been reviewed and are revised to comply with current changes.

TESTING

Instrumentation and Checkout

It has been determined that the Apollo ECS will be compatible with the spacecraft prelaunch automatic checkout concept, and that the checkout procedures and confidence levels will not be affected.

The definitions of the in-flight test monitoring instrumentation for the ECS has undergone radical changes. The cost reduction effort has resulted in fewer in-flight test monitoring instruments than originally proposed; too few for obtaining adequate test results. The minimum basic requirements, therefore, are being reevaluated.

Establishing the ECS checkout system has been slowed because of changes in the ECS design, removal of dual-gas-system components, and cost reduction program changes. The instrumentation diagram is being revised to include the latest design change in instrumentation requirements.

Preliminary detail test requirements were determined for airframe 008. These include the prelaunch, Earth orbit, reentry, and earth landing mission phases which will be simulated in a vacuum chamber at the Arnold Engineering Development Center.

Laboratory tests were initiated to obtain a satisfactory welding method for the aluminum-suit-circuit ducts. Tube joining by means of a union collar and solder, or fusion-weld methods, are being considered as a means of preventing an excessive weld penetration and possible high-pressure drop.

As a result of the cost reduction program, the hard-vacuum test fixture was deleted.

New environmental system requirements for simulators and evaluators were established. Special cooling, air conditioning and waste disposal systems will be designed.

Each ECS control will be calibrated on a special test setup, following completion of fabrication and assembly. The controls will then be tested and modifications will be made if required.

A study will be conducted to investigate the feasibility of obtaining adequate post-landing ventilation by removing the hatches. This would permit the deletion of the manual valves which have replaced the snorkels.

ECS breadboard testing information concerning interior wall temperatures, heat rates, metabolic rates, and electrical loads will be prepared. The detailed breadboard test plan will be released during the next report period. An ECS space radiator test panel will be built according to the latest size information.

Boilerplates

Design and detail for the telemeter coldplate in boilerplate 12 are complete. The "C" band transponder coldplate is also complete and detailed. An insulation (1-inch fiberglass material) drawing for boilerplates 13 and 15 is complete.

Schematic wiring diagrams for boilerplates 12, 13, 15, 22, and 23 were prepared and approved. Water-glycol tanks and accumulators for boilerplates 13 and 15 were sized for system volume at both extremes of encountered temperatures; their location in the command module was established. A water tank for the research and development instrumentation cooling system was decided upon for boilerplate 12, and the location in the command module established.

Cooling system design for boilerplates 13 and 15 is now being firmed. The installation drawing for the coldplates will be released when the plate location is established. Specifications have been written for the thermal control valve and the pump assembly. Also complete is the specification for the integrated heat exchanger.

Boilerplate 12 was restudied in the light of the latest criteria for launching time and reduced solar load. The resultant cooling system consists of a 40-pound tank of water, two coldplates for telemeters, and two coldplates for "C" band transponders. The water is pumped by motor-and-pump combination through the coldplates by means of power from a NASA-supplied battery. A quick-disconnect filler connector is provided for GSE servicing of water.

Mock-ups

Layouts of the suit-circuit ducting are completed for mock-ups 2 and 18. All drawings for these mock-ups have been released. Components are being fabricated for the interior mock-up 2.

Drawings of the cryogenic tank installation for the service module are being prepared. All drawings released for mock-ups 2, 5, and 7 are applicable to the complete systems mock-up 18.

Water, urine, and chemical tanks and a wood mock-up of the vent line were installed in mock-up 5. The revised configurations resulting from the center of gravity-shift will require rework of many mock-up 2 components. The cryogenic storage tanks have been installed in mock-ups 7 and 18, but without the heat exchangers.

The first of the three 1/6-scale mock-ups is complete in component, structure, wiring, and plumbing detail. The color coding is similar to that on the full-size models.

GENERAL

Packaging

Studies have been conducted concerning the possibility of repackaging the main ECS package. Results indicate that by deleting the third-unit compressor and two sponge-type water separators and incorporating the wick-type separator, package volume could be reduced considerably. In addition, the center of gravity of this 200-pound package could be shifted approximately 14 inches toward the lower equipment bay. The high-pressure, reentry oxygen subpackage and the glycol reservoir would be included.

Spares

The ECS and GSE components and instrumentation were analyzed to determine preliminary spares requirements and justification. Support will be provided concurrently with the delivery of production ECS and GSE hardware.

ASSOCIATE CONTRACTOR ACTIVITIES - MIT INSTRUMENTATION LABORATORIES

The composition of coolant fluid (glycol, water, and inhibitors) tentatively recommended for the ECS is being forwarded to MIT. In the event that an integral coldplate is incorporated into the sextant-telescope package, MIT will perform compatibility tests of the fluid with beryllium copper.

SUBCONTRACTOR ACTIVITY - AIRESEARCH MANUFACTURING COMPANY

The AiResearch program plan was reviewed and approved; the AiResearch statement of work is being revised. Three AiResearch and three Beech Aircraft specifications were received for review and evaluation. Subcontractor hardware utilization schedules were prepared for both AiResearch and Beech Aircraft.

Since AiResearch is responsible for developing the female half of the pressure suit, it is necessary to coordinate the design with S&ID, the designer of the male half.

The development testing stage of the AiResearch effort is continuing on schedule with 20 percent of the components being tested.

Facilities

Next month the interim test facility, located on the east side of building 128, will be completed and available for the program. The test chamber will be pressure-and-leak-tested. Vacuum feed-throughs for temperature, pressure, flow rate, and power will be installed.

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EARTH LANDING SUBSYSTEM

PARACHUTE

Drop test 7 was conducted to repeat the previous drop at parachute design conditions (64q, 15,000-foot altitude). The test article was a ringsail canopy, 88 feet in diameter. The drop was normal, and the desired drop conditions were achieved. The reefing time was observed to be less than the prescribed 6 seconds. Minor canopy damage occurred with tears in three sails and small tears in the deployment bag.

Drop test 8 was conducted to determine whether the single main parachute could withstand deployment at 1.5 times the design dynamic pressure. This represents the ultimate load condition of the parachute. The obtained Askania data conflicted with the reported drop conditions, so the exact dynamic pressure at drop could not be determined. The test will be repeated, using a bomb-bay-type aircraft to reduce errors in drop conditions.

A meeting with Northrop-Ventura resulted in an all-out effort to obtain and use bomb-bay aircraft in all future tests. Procedures will be set up to obtain "quick-look" Askania data within 24 to 36 hours after each test rather than the normal 7 to 10 days.

Due to the expense of drop tests, a study was conducted to determine the requirements for a back-up telemetering receiver that would supply the data otherwise lost.

The weekly design review meetings with Northrop have produced a design philosophy covering the various components of the parachute subsystem. Firm envelope outlines for the drogue chute and pilot chute mortars have been established. The sequence control package is presently under study, while the sequence control schematic is considered firm.

A design-study layout has been completed of the baroswitch static-pressure pick-up locations.

Parachute-disconnect method studies have produced tentative designs for both the main and drogue parachute release mechanisms.

The first test film from the Langley command module drogue tests has been reviewed.

SUBCONTRACTOR ACTIVITIES NORTHROP-VENTURA

A definition of data required for the parachute drop test program was forwarded to Northrop-Ventura. This requirement describes the photographic, telemetric, and phototheodolitic data necessary to evaluate system performance. Northrop-Ventura has been directed to proceed on the reduced drop-test program. The weighted bomb drop tests series is in process. The Parachute Test Vehicle series will start during the next report period.

FORWARD HEAT SHIELD

Several closed bomb shots were made during the past report period.

A test program was initiated for determining the effects of pitch and roll, motor fuel, vapors, and products of combustion on parachute materials. Early tests will be exploratory followed by a formal program.

FORWARD HEAT SHIELD SEPARATION SYSTEM

Six firings were made, using two types of powder at progressively increased loads, to determine required pressures. Additional tests will be conducted using the Hercules powder to obtain the additional data needed for test evaluation.

The data resulting from the closed bomb tests will be useful in determining the propellant required for heat-shield ejection.

Action has been initiated for 18 drogue model parachutes for wind tunnel tests.

COMMUNICATIONS SUBSYSTEM

RADIO FREQUENCY ELECTRONICS

DSIF Transponder

DSIF equipment is being relocated to the command module.

A Hughes traveling-wave tube has been selected for use in the power amplifier. Design of this equipment is proceeding.

Study continued on the use of DSIF equipment in a unified communications system. Two presentations on this concept were made to NASA. During the next report period, modulation techniques for DSIF equipment will be revised and defined, and suppliers for the DSIF transponder and C-band beacon will be recommended.

Unified Communication Study

It was concluded that the communication system could not be unified in time to flight-qualify the system prior to first manned flight. Consequently, the present near-earth equipment will be retained for the early manned missions. The unified system could be phased in after system qualification.

Personal Communications

The revised S&ID concept recommendation for personal communications consists of a duplex capability with a simplex capability back-up. Astronaut transmission will be on 296.8 mc with a reception capability on 296.8 mc for simplex. The frequency for duplex operation has not been selected. Simultaneous transmission of voice and biomedical data with a break in capability will be possible with this system. Two changes in spacecraft VHF equipment required for compatibility are a dual-channel receiver in place of single-channel receiver and a diplexer for use during duplex operation.

It was determined that locating a loudspeaker in the spacecraft would not increase the power requirement and would increase weight not more than 1.5 pounds.

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Radio Recovery Aids

Design of the HF transceiver design has been reoriented to the use of AM modulation instead of a single sideband.

Available power for the VHF beacon A is undergoing additional study. It now appears that 833 watt-hours are available, and methods to attain 72 hours full operation of the beacon are being sought.

During the next report period, a recovery aid will be established, requirements of the compatible beacon will be defined, and procurement action will be initiated.

DATA SYSTEMS

Data Storage Equipment

Feasibility of a proposed tape transport design is being evaluated.

Specifications are being revised to reflect changes in pulse-code modulation (PCM) equipment.

Telemetry Equipment

Bids on PCM telemetry equipment have been reviewed.

Specifications are being revised to reflect reduced operational measurements and the effects of spacecraft prelaunch automatic checkout equipment (SPACE) implementation.

A report on the synchronization study has been completed.

Premodulation Processor Equipment

This equipment has been functionally defined, and work on a performance specification is starting.

TV Equipment

A final procurement specification for the TV equipment is in work and will be completed during the next report period.

Signal Conditioners - Collins Radio

S&ID and Collins Radio jointly reviewed signal conditioner design status. Preliminary specifications for signal conditioners were furnished by Collins.

Signal conditioning will be reevaluated considering the new requirements of 260 measurements.

A meeting was held with Collins representatives to establish the signal conditioner packaging concept. Flexibility of use was emphasized

OPTICAL EQUIPMENT

The final optical report summarizes all activity on the periscope and associated photo systems from inception of the program to deletion from the vehicle.

Engineering evaluation tests using the Sun-Gun lighting equipment proposed for use on boilerplate impact tests have been completed. Design installation drawings for lighting circuitry are 90-percent complete.

During the next report period, specifications will be completed for one 16 mm motion picture camera and one still camera on the operational Apollo spacecraft.

ANTENNAS

Beacon

Development of beacon antennas was begun, and a date was scheduled for the first fully qualified unit.

Telemetry

Work was initiated on this equipment. S&ID furnished the subcontractor a one-third scale model of the command module and the escape tower for pattern tests.

Radome

The procurement specification is complete and will be released during the next report period.

SUBCONTRACTOR RELATIONS

Hughes Aircraft Company, Motorola Incorporated, and Resdel Engineering Corporation have made proposals on the DSIF transponder.

Collins Radio has received bids on the C-band beacon from Aero-Geo-Astro, American Car and Foundry, Hazeltine, Motorola, Scope, and Temco.

Transco Products, Incorporated, was awarded the telemetry antenna contract.

The radome component specification, multiplexer specification, and diplexer specification were determined at coordination meetings with Collins Radio. S&ID gave Collins Radio new information on radome heating rates for inclusion in their specification.

Collins Radio has selected suppliers for "buy" items, and contracts will be negotiated.

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NAVIGATION AND GUIDANCE SUBSYSTEM INTERFACE

Interfaces for the navigation and guidance telemetry, the stabiliza- tion and control system (SCS) steering and propulsion signals, and the electrical power are being defined.

S&ID plans to meet with MIT to establish procedures for approval of the interface control documents and to expedite updating.

S&ID estimates that the addition of spares, optical eyepieces, and cabling provisions has increased the guidance system weight over the target weight. The S&ID weight reduction program will be presented to MIT during the next period.

A partial Apollo guidance equipment (System O) mock-up has been received. The mock-up includes the navigation base with optics, the inertial measurement unit and computer configuration.

S&ID and MIT will meet to work out a controlled combined approach for the reduction of electromagnetic interference.

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COMMAND MODULE STRUCTURE AND SUBSYSTEM INSTALLATION

BOILERPLATES

Boilerplate 1 (Command Module Land and Water Impact Vehicle)

The first land drop test resulted in a slight delamination of the aft heat shield inner skin. The damage was confined to a small area near the point of impact.

This boilerplate also underwent four water-drop tests at the interim facility. The drop weight was 8450 pounds, the drop height was 99 inches, the vertical impact velocity was 23 feet per second and the horizontal velocity was zero. The heat shield was retracted. The pitch angles were 5, 15, and 31 degrees.

Boilerplate 2

The aft bulkhead is complete and being welded to the main shell. The aft bulkhead was welded to the floor beams. The inner wall segments were joined together and welded to the aft bulkhead. The installation of doubler plates has begun. The aft heat shield, including ballast, is completed, except for fittings. The forward bulkhead is nearly complete.

Boilerplate 14

All drawings for boilerplate 14 (house spacecraft 1) will be completed during the next period.

Boilerplates 3 and 19 (Prequalification Flight Drop)

The supports for the simulated pitch controller were released for boilerplates 3 and 19. This release completes the simulated equipment that attaches to the forward bulkhead. The structure rework in the aft bulkhead area to accommodate C-133 air-drop sway-pad loads is complete. Two new drawings and installation orders are complete for reinforcing eight side stringers for C-133 sway-pad loads. This rework will involve the use of mechanical fasteners.

Complete impact attenuation systems will be retained on boilerplates 3 and 19 to improve chances for capsule reusability.

Boilerplate 6 (Pad Abort Test Article)

The equipment support structure for boilerplate 6 is being designed to the emergency landing condition pending further investigation of actual requirements. Information concerning ballast for the aft heat shield was released.

Work is complete on the forward bulkhead and parachute compartment of boilerplate 6. A study is under way to provide additional adjustment on the command-to-service-module thrust fittings.

The redesign of the forward bulkhead and the forward heat shield, including relocation of the parachute-attach fittings, was released for boilerplate 6. The redesigned bulkhead is being fabricated.

Changes in gyro mounting on boilerplate 6 are being investigated, and a new layout of pressure sensor location was received.

FABRICATION

Highlighting last month's activity was the formal acceptance by NASA of mock-up 12 (crew support system), mock-up 5 (cabin exterior equipment) and evaluator 2 (life systems). After acceptance, the mock-ups were moved to the review area at S&ID where they will be held for development and study purposes.

The basic structure for boilerplate 3 was completed last month, short the pitch controller assemblies used for attachment of the parachute systems. Special arrangements have been made to install these parts at the engineering site. Other significant boilerplate activity was noted on the completion of tooling and start of assembly operations on boilerplates 6 and 9, increasing the number of boilerplates in work to five.

Looking to November, effort will continue to complete systems installation in mock-up 11, 18 and 2. In the boilerplate area, concentrated effort will continue on final installations and delivery of boilerplate 3 to Northrop-Ventura, and the delivery of boilerpate 2 to engineering test.

Emphasis will be made for structure completion of boilerplate 6 by the 23 November schedule. November will also see the beginning of spacecraft detail fabrication for AFRM001, the preparation of tooling and facilities for spacecraft assembly and increased activity in the Apollo Test Requirements Program.

Crew Couches

The improved crew couches developed for boilerplate 6 and 21 will be used on boilerplates 1 and 2, because couch requirements for boilerplates 6 and 21 were deleted. The couch and crew mass were simulated by a steel platform in the boilerplate 1 water-drop tests.

Complete Vehicle

A control layout of the forward compartment, showing revised antenna locations and removal of the redundant drogue mortar, was prepared for incorporation into mock-up 18. A drawing was made of a proposed design of the snorkel shutoff valve control that will be installed on mock-up 18. Information on the revised crew couch adjustment range and other couch structural changes is being applied to mock-up 18.

HEAT SHIELD

Forward Compartment

Apollo Test Requirements

Several major revisions incorporated in the design of the spacecraft forward compartment heat shield have changed basic load paths to such an extent that a test of the Apollo Test Requirements (ATR) released parts originally required would be of little value. Stop orders were issued on some component drawings.

For the heat shield of the forward compartment fourteen drawings, all honeycomb panel face sheets, two honeycomb panels, and engine access door panels were released. The remaining two honeycomb panels and access door face sheets are being completed.

Pressure cartridge propellant for forward heat shield jettison tests (ATR 108) was received; it will be tested in a closed bomb for burning rate. Closed volume tests of propellants for ATR 108 are complete.

Design

Master dimensions are established for the launch escape tower leg wall. A design layout for the installation of the new, ablative, attitude-control engines is in work. Eighteen forward compartment heat shield drawings were released. All honeycomb panel components of the forward heat shield will be released during the next period.

Analysis

A weight comparison between steel and glass-fiber components for the forward heat shield shell and fittings was made.

A deflection analysis of the forward face of the heat shield at Xc=110 for a case in which only two ejectors operate was conducted. The calculations are being refined to include the effects of adjacent shell support. Analysis is continuing on the tie-down fittings, cut-outs, access doors, and the reaction-motor supporting structure.

During the next period, several gas generator grains will be evaluated to find a faster burning grain for the pressure cartridge propellant to be used for forward heat shield jettison tests.

Crew Compartment

Design

Design studies are being made to eliminate the blowout panel.

Analysis

A mathematical model was selected to represent the forward portion of the crew compartment heat shield; it accounts for the structural discontinuity in the emergency egress panel. Additional computer runs are being prepared, utilizing spring constants for the heat shield stringers located between the main longerons of the inner cabin structure.

A weight trade-off for various methods of attaching access doors is complete. Analysis directed toward reduction of thickness requirements of the access-door edge member has been completed.

Results of a detailed analysis of the crew compartment heat shield frame will be published during the next period.

Aft Compartment

Design

Studies of the installation of the umbilical plug and the coaxial cables are complete. A few design details of the hard-line study are still to be resolved. Four new drawings, defining the insulation pads for the attach fittings, were released.

Analysis

Work continues on the internal load distribution analysis for the pad abort condition. The analysis presupposes six unsymmetrically positioned tension ties to the crew compartment.

Ablative Material

Requirements

Effort is continuing on the need for vents between (a) the outside atmosphere and the command module inner shell, and (b) outside atmosphere and the space between the inner and outer shells.

Subcontractor Activities - AVCO

The heat shield procurement specification and the Avco work statement are being revised to incorporate the changes made in the recent cost and weight reductions. Procurement specifications were revised to limit weight to 1100 lbs. and to change space environment temperatures from -260°F to +40°F on the aftbody.

Tests

The tensile test load versus strain curves were obtained for the command module reentry heat shield component test. This test will determine the mechanical properties of 5026-22 ablative material.

Command module reentry heat shield component radiant heat oven recalibration was completed.

IMPACT ATTENUATION

Design

The aft heat shield shock attenuation was deleted by NASA request. However, structural mounting provisions for the vertical air-oil and the horizontal crushable honeycomb struts will be retained on boilerplates and airframes.

The heat shield was slightly damaged in the water drop tests of boilerplate 1 and 2. The damage is to be expected, in the fixed-shield philosophy which views structural deformation as an aid to the attenuation of crew-couch shock.

Analysis

Impact characteristics of the Apollo spacecraft by using vertical and horizontal drop velocities with pitch angle and appropriate geometry, will determine the accelerations and relative velocities and displacements of the crew, the pressure hull, and heat shield from impact to some minimum energy level.

Analysis of the 1/4-scale drops (at horizontal velocities of 0, 30, and 50 feet per second onto level clean sand) with heat shield up revealed very good slideout capabilities. Capsule stability was better with heat shield extended.

CREW COUCHES

Design

The two support links on the sides of the seat pan and the scissors assembly for transferring side shear from the seat pan to the lower cross beam were combined into one part.

A layout to support the study on relocation of the center of gravity during reentry is in progress. The study involves moving the men and couches approximately 10 inches toward the aft equipment bay for the reentry phase, and then repositioning them for landing impact. A review of body angles used for existing couch geometry disclosed that the thigh-to-torso angle could be sufficiently closed, for a brief period, to shorten the over-all couch length by the required travel along the Z-Z axis.

The more acute angle is desirable for high g conditions, rather than the former angle which was selected for comfort considerations. This change in the couch adjustment range, plus a revision in the lower leg angle to gain structure clearance, necessitated considerable redesign of couch structure and kinematics.

The center couch is stowed by removing the basic support assembly (consisting of back structure, seat pan, and the remaining body-support components) from the two center Y-Y axis beams. This is accomplished by pulling four pins. The center couch beam segments are removed and stowed separately.

The deletion of personal parachutes and survival kits resulted in some redesign; this was coordinated with the angle adjustment revisions. Alternate couch-shock systems, including friction attenuators, fluid, and fluid-pneumatic struts were studied.

Analysis

All crew-couch shock absorption is a function of the three-couch shock-strust systems, because the aft heat shield impact attenuators and the roll orientation were eliminated. Without roll orientation the Y-Y axis

S&ID provided Avco with preliminary layouts of the view-port covers and pointed out problems concerning permissible closure cracks, plugs, and ablative material fasteners.

FORWARD HATCH AND RADOME

A layout for the mechanical locking mechanism to prevent turning of the breech type lock (located in the forward end of the hatch) was completed. The detail prints on the forward radome hinge were completed. Detail drawings on the forward hatch-cover-locking mechanism are 70 percent complete.

FORWARD COMPARTMENT

Work is continuing on a stress check of the forward compartment. An analysis of the drogue parachute mortar attachment fittings is under way. A preliminary analysis, using an elastic foundation principle, was performed to determine the feasibility of bonding a fitting to the bulkhead outer face sheet to carry shear and compression mortar-mount loads.

METEOROID ANALYSIS

The analysis of the Apollo vehicle, (command module, service module, adapter, and fairing) was completed.

SYSTEMS EQUIPMENT INSTALLATION

Forward Compartment

The location of the high frequency antenna and the very high frequency antenna were exchanged. The shift will reduce antenna interference with the parachute attach point and provide clearance with the heat shield.

The control layout is being revised to show the location of the new pitch engine configuration, the forward access hatch, and line routing. Further definition of structure and access will be incorporated.

S&ID determined the six coaxial line penetrations through the forward bulkhead are sufficient.

Crew Compartment

Three configuration studies were made to determine what effect relocation of crew compartment equipment would have on the center of gravity location. These studies indicate that the maximum lift/drag trim obtainable by relocation of equipment is approximately 0.4 (right to left) struts require strokes equal to that of the Z-Z (head to foot) struts. Due to space limitations, however, the Y-Y struts cannot be changed from the original configuration.

Results from the 1/4-scale model drops at Langley indicate favorable slideout for a command module landing on smooth, level, dry sand. The remaining energy could easily be absorbed by the present short-stroke Y-Y struts with acceptable crew attenuation levels because of the much longer X-X and Z-Z strokes. Extensive tests of the 1/4-scale model landings on varied terrain at high horizontal velocities were requested to gain a better picture of crew survival along the Y-Y axis.

Crew-couch impact-attenuation system kinematics remain essentially the same.

CREW ACCESS HATCH

Elimination of personal parachutes nullifies consideration of a blowout emergency escape panel. A set of quick-acting latches for the inward-opening crew hatch is required to provide a means for ship abandonment following forced landing. The hatch now has multiple threaded fastenings along the lower edge. The required latches must be capable of operating from the outside as well as from within the pressure vessel. Outside operating hardware for securing the outer ablative panel over the crew door is required as well as a method for releasing it from inside.

Tests of linear-shaped charges showed that the noise level of an explosive emergency escape hatch is within human tolerance. RDX linear-shaped charges of 10, 25, and 50-grams per foot were tested. Noise levels were recorded inside a crew helmet located the proper distance from the charge.

AIR LOCK AND DOCKING

The lunar excursion module currently under study is capable of serving as an air lock for transfer of personnel to space; it is docked to the command module during the translunar phase.

VIEW PORT COVERS

Proposal designs for the crew-hatch window, docking ports, and earth landing windows were prepared. Design planning called for these port covers to operate solely in the space environment. Recent redirection toward studies of operation during boost, high altitude abort, and jettison prior to landing have introduced unforeseen operating-load conditions which could force some redesign.

Aft Compartment

A study layout of the proposed reaction control engine reorientation has been started. The study will determine the feasibility of reorienting the yaw engines parallel to (and the roll engine normal to) the line of flight during reentry.

The location of the helium pressurization system for the reaction control system (RCS) propellant tanks is changed from near the negative Z-axis to near the positive Z-axis. This change moved the center of gravity approximately 0.6 inches in toward the positive Z side.

Work is being done on the design for hard-line penetration in the aft sidewall.

NAVIGATION BASE INSTALLATION

S&ID and MIT exchanged information on the interface between primary structure and the navigation base. The primary support points and the seal interface were discussed.

Inner Cabin Structure

The structural evaluation of the navigational equipment support structure is completed. Computer program runs were made on the crew compartment located under the pad abort pressures. Results received are being evaluated.

Thermal Stress Analysis

A thermal analysis is underway to calculate the interaction between the inner shell and crew compartment heat shield, and to determine resultant structural and ablator stresses.

Ground Support Equipment

The stress of the command module aft and sidewall inner skin assembly for vacuum cup pick-up was checked.

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Weight Control

The command module current weight was reduced to 8760 pounds by incorporating the following modifications:

(a) Deletion of the aft movable air lock section.

(b) Revision of ablator thickness fairing method.

(d) Addition of two windows for the lunar orbital rendezvous mission.

Weight studies on alternate methods of cooling and mounting electronic equipment are in progress.

Alternate designs of the umbilical disconnects through the ablative heat shield are being studied to offset the weight increase imposed by current design. The alternate designs propose pyrotechnic severing of the wire bundles. Alternate materials for the supercritical storage system to reduce weight also are being investigated.

MATERIALS AND PRODUCIBILITY

Forged Rings

Two samples showed no weld cracking during phase II of the evaluation of single- and double-pass welding techniques on 2014 aluminum alloy rolled-ring forgings. The samples were marginal because they deviated the most from the optimum grain, but they were within the limits of specification requirements.

Phase III evaluation of the flash-welded rings has begun. This method is a more positive control of the metallurgical structure of the starting material. Preliminary data indicate that heat treated flash-weld-joint efficiencies of 92 to 95 percent of parent-metal strengths were obtained.

Brazed Honeycomb Sandwich

Two brazed heat shield fabrication programs are under way. In one program, a panel of Rene' 41 brazed sandwich is being fabricated, and will be tested for mechanical properties at elevated temperatures. The second program involves preliminary screening of brazed honeycomb panels by testing mechanical properties at 1800 to 2000 F.

Finishes

A literature search was completed and special coating methods from suppliers were examined in a program to provide a coating to prevent corrosion, resist sublimation, and avoid hydrogen embrittlement when applied to high strength steel fasteners in thickness of 0.0002 to 0.0006 inch.

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Adhesives

Data were developed and are being analyzed from phases I and II of the study of the effect of Apollo environment on adhesive systems for structural bonding. In the investigations, all lap shear and honeycomb tensile specimens were fabricated and tested in a vacuum environment of 10^{-9} Torr, and all bonded specimens were tested at 300 F and 500 F.

Pressure Vessels

Refinements of the proposed phase I program to develop pertinent design data for filament-wound pressure vessels for the Apollo were completed.

VIBRATION AND ACOUSTIC TESTS

Command Module Panels

Dynamic ablator-covered panels were subjected to preliminary shock excitation tests by striking freely suspended panels with a rubber mallet. The purpose of these tests is to determine the natural modes of the panels.

Reinforced Fiberglass Structural Members

Reinforced plastic 1.08-inch I-beams of a high temperature phenolic resin fiberglass system, approximately 0.060-inch thick by 45 inches long, are being fabricated. These test sections will be subjected to vibration and acoustic tests to establish design allowables for this type of construction. Apparent weight is 0.07 pounds per linear foot for the completed reinforced plastic I-beam. This program will determine the feasibility of using reinforced fiberglass structural members between outer and inner shells of the command module.

STRAIN GAGE EVALUATION

A test program was written for the high temperature strain evaluation program. Work is in progress on two materials (Titanium and PH15-7M) at temperatures up to 800 F.

BEARING TESTS

Three tests of anti-friction ball bearings were begun. Thirty-eight ball bearings (R-3 size), lubricated with gold film and silver film will be operated for 14 days in a series of 19 tests. Speeds will range up to

3350 rmp, at temperatures from -200 F to 450 F, and in a vacuum of 10^{-9} Torr in various combinations. Twelve anti-friction ball bearing tests will be concluded during the next period.

RELEASE MECHANISMS

The test specimen for strength, vibration, and functional tests of the command module release mechanism was received.

Phase I of the forward compartment heat shield release system test program is complete. Delivery of the aft heat shield release mechanism hardware was begun.

Strength and functional tests of the command module release mechanism will be completed during the next period.

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SERVICE PROPULSION SUBSYSTEM

PROPELLANT SYSTEM

An investigation is now under way to determine the feasibility of bubbling the pressurant through all four propellant tanks instead of through each upstream tank only. Design layouts of the propellant tank and access door have been started. The propellent-distribution-system tank feed-out "Y" assemblies were redesigned to utilize a single feed-out elbow, thereby reducing system pressure drop. Propellant system and engine feed line interface locations were determined. Design layouts of the series feed-propellant tankage and distribution system will continue concurrently with studies to achieve an optimum system design.

PRELIMINARY FLIGHT RATING TEST (ENGINE TEST STAND)

All three test fixture structures and five cylinder sections for the propellant tanks have been fabricated.

A design layout of the propellant distribution lines is in progress. Effort is being made to incorporate a large safety shut-off valve into the simulated distribution line routing, with a minimum deviation in flow path.

Design layouts are being made of the engine mounts and gimbal actuator supports. The possibility of incorporating a thrust measurement system into the engine mounting is being studied.

The PERT network was updated to the latest activity arrangement. Completed activities were indicated on the network.

In compliance with Contract Change Notice 7, the automatic propellant utilization is being deleted from the service propulsion system (SPS). (Ref Program Management p6)

Studies are being conducted to determine the over-all effect on the mission and the feasibility of alternate systems.

Helium leakage rates will be determined after pressure cycling and reuse.

The process specification for checkout and operation of the text fixture will be completed.

MATERIAL COMPATIBILITY

Butyl Rubber Evaluation

The weight loss of the Stillman SR 634-70 butyl rubber compound, after 90 days exposure at 1 x 10^{-9} Torr vacuum conditions, has been determined. The weight loss, less than 1 percent, is considered insignificant. This material has therefore demonstrated its stability under hard vacuum.

O-ring Evaluation

Nitrogen tetroxide permeability tests have been completed with the SR 634-70 compound in both the sheet and O-ring forms. The nitrogen tetroxide permeability across the O-ring in a flange-type installation was slightly less than that measured across the sheet directly exposed to propellant. Nitrogen tetroxide permeability tests with FEP and TFE Teflon sheet have also been completed. The Teflon film is found to have approximately one half the permeability of the TFE Teflon film.

Teflon O-rings will be tested during the next report period for permeability to nitrogen tetroxide. The results will be compared with those reported for the TFE film.

Seal Evaluation

Preliminary helium leak testing of butyl rubber and Teflon O-rings was completed. The butyl rubber O-rings had leakage rates of 10^{-6} to 10^{-8} standard cubic centimeters helium per second and the Teflon rings had a leakage rate of 10^{-5} standard cubic centimeters of helium per second at 4500 psig. The leakage rates of the butyl rubber O-ring were lower when the seal was tested in a diametrical (shaft type) installation than when it was tested in a face (flange type) installation. After the test fixtures were heated to 160 F for 24 hours, the leakage rates decreased; apparently due to the softening and redistribution of the seal material at this temperature.

The compression set and volume swell of the SR 634-70 O Rings exposed to nitrogen tetroxide will be determined, and similar tests will be started with Aerozine-50.

Elastomer compatibility tests have been completed under the Phase I program for seals. A report is being prepared. Compatibility tests will be continued under the Phase II program.

An expulsion bladder mold has been completed.

Approximately 100 helium leakage tests have been conducted on metallic and nonmetallic seals. All fixtures currently on hand have been proof-checked to one-and-one half times the operating pressure. All nonmetallic seals have been subjected to the probe-and-leak screening tests. Thirty percent of the nonmetallic seals have completed the temperature cycle phase. Approximately 20 percent of the metallic seals have been subjected to the preliminary proof and leak tests. These seals are currently starting the thermal cycle phase.

The proof-pressure, leakage, and thermal-cycling phases of the nonmetallic seals will be completed during the next report period.

Tests will be initiated on metallic and nonmetallic seals to determine the effects of 500 pressure cycles.

Connector, Pressurization, and Propellant System

Premabraze 128, an alloy of 72Au-22Ni-6Cr, has been selected for the propellant and pressurization systems.

Tube Welding and Brazing

The split induction tool has been cast and is working well. Two split caps are being machined to create a bearing surface for tube alignment and a better seal for retention of the inert atmosphere.

The infrared temperature-detection system is operating, but at a low rate of sensitivity. The circuit will be modified and more resistance added to increase sensitivity to the desired level.

Tests have been completed on the nitrogen tetroxide compatibility of four gold brazing alloys. None of the alloys showed significant weight loss after immersion for 30 days at room temperature. Premabraze 128 was selected for further evaluation, based on its superior wetting properties.

SUBCONTRACTOR ACTIVITIES

All purchase requests to buy "off-the-shelf" equipment for the three PFRT test fixtures have been released.

Requests for proposal have been sent to prospective suppliers on the helium system pressure regulators. Helium system specifications for the solenoid shutoff valve check and the fuel/oxidizer system fill-and-drain disconnects have been released.

Materials have been received for joint design tests and other tests included in the program. An automatic tube welder is available. Welding operations will be started in the next report period on the one-inch aluminum tube material. The titanium-tubing test program has been delayed, pending delivery of a 3/4 inch automatic titanium tube welder. Delivery and tests have been scheduled for the next report period.

Release of the process specification for purging and cleaning propellant systems has been delayed because of problems of applicability to specific systems. A specification of more general applicability is being prepared for issue during the coming month.

During the next report period, proposals for the helium-system pressure regulator will be reviewed, an expulsion bladder for test purposes will be delivered, subcontracting of hard vacuum and radiation tests on elastomers will be negotiated, and testing will start. Impact-sensitivity screening tests will also be started.

ROCKET ENGINE

Subcontractor Activities - Aerojet General (Rocket Engine)

The engine procurement specification has been completely revised and prepared for formal release. The specification will be reviewed in detail with Aerojet before release.

Engine Installation

The placement and orientation of the engine within the vehicle, and the location of the actuator tie points and propellant feed lines, have been determined. Layouts are being processed which will complete all engine-to-vehicle interfaces. A detailed comparative study of the various methods for gimbaling the engine will be completed during the next report period and transmitted to NASA.

Test Program

The Aerojet test program at Sacramento has been initiated with full-scale ablative-chamber firings. The Aerojet Azusa operations have been expanded to include water-cooled steel chambers.

Aerojet has implemented a revised program concept and schedule which deletes the PFRT program, reschedules engine qualification to July 1964, and completely reschedules deliverable hardware. This change provides an additional 9 months for engine development, and is consistent with the availability of Aronold Engineering Development Center (AEDC) altitude facilities for conducting the altitude qualification tests.

Hardware for use at AEDC during the forthcoming subscale altitude test program has been acceptance-tested and shipped to Tullahoma, where it will be ready for use when the facility becomes available.

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SERVICE MODULE STRUCTURE AND SUBSYSTEM INSTALLATION

FABRICATION

The service module for mock-up 9 was structurally completed during this period, and further effort continues on the installation of systems in mock-up 18.

Initial assembly operations were started on beam structures for the first aluminum service module to be used in conjunction with dynamic tests of boilerplate 9.

At NASA direction, three boilerplates and one spacecraft service module are being redesigned for direct attachment to the Little Joe II booster. Final approval of this change is pending the completion of contract change negotiations.

Accomplishments scheduled for next month include completion of installations on mock-ups 9 and 18, and delivery of mock-up 7A to Engineering. Work is also scheduled to begin on assembly effort for the service module for boilerplate 13.

STRUCTURAL DESIGN

Boilerplates

The location of the electrical disconnect has been made final for boilerplate 9 and subsequent boilerplates.

Configurations have been studied for a seal between the command module and the service module.

A thrust fitting has been designed that provides adjustment in three directions; this eliminates the mating problem between the command module and the service module.

The fuel and oxidizer drawings, the aft bulkhead assembly, and the truss fitting drawings for boilerplate 14 are being readied for release.

All drawings will be completed for boilerplate 14 (house spacecraft 1) during the next report period.

Primary Structure

The service module shell tie to the radial beams has been revised. A simple tie will be used with a single row of bolts around the perimeter of the shell sections. The moments were derived from shell analysis of incremental circular-ring frames without the six-beam restraining points present in the service module.

Initial release of radial-beam detail parts was scheduled for October; however, the schedule is being revised so that the drawings can be correlated with numerical control manufacturing of the major portion of the radial beams.

Final results of a symmetrical-shell program for solving shell loads without frame energy will be obtained during the next report period.

All problems in the center-frame solutions will be completed, and output checkout of the unsymmetrical redundant-structure preamble (revised and refined) will be concluded.

DSIF Antenna

A preliminary design was completed for deployment of the deep space instrumentation facility antenna (DSIF) to the y-axis. Under this design the antenna is shifted into a deployed position by actuation of a spring-loaded swing-out arm. This system may require revision if a revised antenna location under consideration is adopted.

Tanks

The Apollo general tank specification and the main propellant tank procurement specification have been completed.

A study is being made of the feasibility of using internal tank structure to support probes and standpipes. It appears feasible to design supports that attach to the lower door frame and upper end boss. This will not require attachment to, or support from, the cylindrical portion of the tank.

During the next report period, studies of oxidizer and fuel tank doors will be continued for positioning fuel lines, pressurization lines, and probe attachments.

Reaction Control System Engines

A stationary configuration for the reaction control system (RCS) engines was selected. Mounting provisions, bracketry, and fairing design layouts are in progress for this configuration.

The following studies were initiated to determine the location of the RCS engines:

A 25-inch fixed boom by 25-degree engine cant

A 25-inch arm by 25-degree engine cant, extendible module

A fixed cluster with separate propellant tanks

A radiator flat-pattern layout with overlay of thermo-reaction control system flame pattern

A picture of one-tenth size (no detail) showing three engines clustered at the top of the service module and the fourth engine below station 200, indicating the possible reduction of the ablative material on the outer shell

A panel and mounted RCS engines with or without fairing

System Equipment Installation

Six formal design studies of installation bases for fuel cells have been completed.

The possibility of locating some radiator surface below the station-200 bulkhead underwent design study. For the time being, the location of the radiator area below the station-200 bulkhead is being abandoned.

Six proposals for access doors are complete. These are all for various methods of opening and closing and one of them for openings larger than 6 square inches.

The panels in both equipment bays will be split into two sections with a 16 x 20-inch oval access door in the upper section.

Three 61-pin disconnects through station 200 will be required to supply electric service to the adapter area.

The service propulsion system (SPS) pressurization system plumbing, layout, and mounting shelf has been revised, and preliminary data has been released for mock-up purposes.

Service Module Insulation

Some configuration studies of insulation below the station-200 bulkhead have been completed. A more formal study is under way that will show the minimum space required by insulation to protect the service module understructure and piping.

Servicing Requirements

Repositioning of approximately 75 percent of all external servicing connections is being studied to provide compatible servicing systems for revised cryogenic storage arrangement, electrical power system (EPS) fuel-cell location, and propellant-series feed system.

Separation System

The command module service module separation system has been adapted to these three separate configurations: spacecraft, boilerplates requiring an operating separation system, and boilerplates requiring a nonoperating system. Three separate installation drawings and attendant details are in work.

The size and configuration of umbilical connections are being made final.

Test firings have been made of two sizes of linear-shaped charges to sever honeycomb panels of the service module-to-adapter separation system.

STRUCTURAL ANALYSIS

Mock-ups

A test program to determine allowable stresses for honeycomb panels made of glass-cloth face sheets and paper honeycomb, and for using sunlight for the curing cycle was begun.

Weight Control

The current weight of the service module has been reduced to 10,765 pounds. The weight of the structure was modified by the reallocation of 29 pounds for the engine gimbal support-ring weight.

Preliminary data reveal that a potential weight increase may be required to prevent the service module shell from exceeding 400 F during a 200-second burning period for the RCS. Several configurations are being investigated.

A weight trade-off study was made on the joints of the service module outer shell.

Primary Structure

Structural design of the radial-shear webs for the service module is being optimized. The present configuration calls for two type of web-honeycomb sandwich and semitension field beam.

Stress analysis based on current loads is being made on the radial beams.

Aft Bulkhead

The simulated structure of the aft bulkhead test part for Apollo test requirements (ATR) 301-5 has been redesigned to incorporate the latest design philosophy; the carrying of the axial and bending loads in the service module outer shell.

During the next report period, aft bulkhead joint component tests will be conducted. Also, test-fixture drawings of the simulated service module aft bulkhead will be released, and fabrication will begin.

System Equipment Installation

A study is in progress for sizing members for the service module RCS. The study involves four different configurations and weights for each configuration.

Design studies are being continued on the gimbaling and deployment of the DSIF antenna. The current study considers storing the antenna in the adapter area.

Several design studies for the deployment of the RCS have been completed and submitted for design.

A design layout of the main engine mount has been completed, a study of fuel-cell supports is being evaluated, and a preliminary stress check has been completed.

Separation System

In the service-to-command-module separation system, the problem of reacting the command module tension is currently under investigation. One method considered utilizes an existing shear pad stiffened so that it can react side loads; another method involves fastening a small pad on the command module base heat shield and transferring the load directly into the service module fairing.

During the next report period, latest body loads will be applied to the shear distribution problem on the compression pads. The vertical load distribution has been completed.

The checkout stage of a program to obtain the distribution of shear pads at the command module-service module interface will be fulfilled during the next report period. This program will be fulfilled by applying the principle of minimum strain energy.

MATERIALS AND PRODUCIBILITY

Service Propulsion System Engine Seals

Three design studies of Service Propulsion System (SPS) engine seals are being made. The approaches under consideration are as follows:

A metal shield shaped as a spherical segment, laterally split for removal, with a center hole for the engine throat.

A flexible, corrugated sleeve of nonmetallic compositions. (This could be the best and simplest solution if materials able to withstand engine temperature become available.)

A combination of the above methods with the metal shield somewhat simpler in shape and protecting the flexible seal from direct infrared radiation.

Pressure Vessels

An investigation is being conducted to determine if Apollo supercritical oxygen pressure vessels can be constructed from materials of higher strength-to-weight ratios without affecting reliability. Two distinct approaches toward lighter-weight oxygen pressure vessels are undergoing evaluation.

Bearings and Lubricants

Friction and wear mechanisms are being developed to evaluate the performance parameters of commercially available lubricants that show promise in spacecraft application. Candidate lubricant materials will include the following:

Teflon reinforced with fiberglass

Rufon reinforced with fiberglass

Molybdenum disulfide plus phenolic binder

Molybdenum disulfide mixed separately with different organic binders

A test program was initiated to establish the static cold-welding properties of bearing materials.

Titanium Alloy

A bar, forging, and billet material procurement specification for extra low interstitial oxygen, nitrogen, and iron in 5Al-2.5Sn titanium alloy has been prepared. This material exhibits an exceptionally high notched-to-unnotched tensile-strength ratio at a temperature of -423 F. It will be used primarily for pressure vessels in the cryogenic temperature range and in the pressurization system of the service module.

Aft Bulkhead

Panels employing three joint configurations were tested. Joint-failing loads were 7810, 8000, and 8900 pounds for the -11, -21, and -31 configurations respectively.

The anticipated failing load was 11,266 pounds. In all cases, initial failure occurred in the bond between a flange of the T-section and the skin.

Because of the low failing loads and the mode of failure, additional test specimens will be fabricated and tested. The new specimens will be shorter to reduce the bending moment at the joint, and close control will be maintained on the bond porosity at the joint.

Work is continuing on fixture design incorporating the latest revisions that include uniform reactions.

Due to a lack of instrumentation, the test program of the forward compartment heat shield is one month behind schedule.

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ELECTRICAL POWER SUBSYSTEM

MOCK-UP DESIGN

A developmental incandescent lighting system was made available for study purposes in mock-up 12 (crew support).

Concentrated effort will be made to prepare the power system and wiring of mock-up 18 for the November engineering development presentation.

BOILERPLATE DESIGN

Design of boilerplate 6 is 90 percent complete. The design will be completed when Government-furnished power system equipment and check-out procedures are received.

Design boilerplate 12 is approximately 25 percent complete, and a signal interface has been established with the Little Joe-II manufacturer.

FLOODLIGHTING

Incandescent lamps will be used for floodlighting, because they weigh less than fluorescent lamps and take up less volume while yielding increased reliability and reduced system complexity. A 28 volt lamp is most desirable because of its compatibility with the spacecraft 28 volt dc power system.

Laboratory tests with a 28 volt incandescent lamp indicate that heat dissipation will not be a problem in the Apollo vacuum environment, but a filament or shock mount to meet the vibration environment will have to be developed.

An incandescent quartz lamp has been studied because it is small and has a high concentration of light. A 28 volt filament is more desirable than the 6-volt filament, because it minimizes energy conversion losses and system weight. Several other conventional 28 volt incandescent lamps are being studied.

During the next report period, additional candidate lamps will be analyzed with respect to the Apollo environments and with respect to the light intensities required for proper distribution.

Procurement specifications will be initiated for lamps, fixtures, and controls.

UMBILICALS

All electrical wires through the aft pressure bulkhead will pass through one feedthrough. The wires will be permanently connected and potted to the feedthrough to decrease space and weight requirements and to increase reliability. The feedthrough pin configuration is adaptable for use with tape cable. This concept depends on current investigations of the feasibility and practicality of using tape cable as a general purpose wiring attachment method. This method of immobilizing wire runs reduces the likelihood of circuit malfunction during high vibration.

The possibility of cutting the electrical umbilical wires as the command module separates from the service module and allowing them to burn away has been investigated. Results indicate that this approach is impractical because of the wider hole and larger total space requirement for passage through the aft heat shield.

Requirements for the command module-to-service module umbilical will be completed during the next report period.

Investigation of the umbilical cutting and burning method of separation will continue.

The practicality of using through-the-hatch wiring for ground control and checkout provisions to minimize the requirement for a command module-to-ground support equipment umbilical will be investigated.

CIRCUIT BREAKERS

A preliminary study of circuit protectors is complete. In addition to fuses and limiters, three types of circuit breakers were considered. The thermal type of circuit breaker was considered most satisfactory in spite of its derating requirement in a vacuum environment.

The circuit breaker study will be continued during the next report period to determine characteristic curves in a vacuum environment so that the circuit breaker and wire characteristics may be matched in a vacuum environment as well as at sensible altitudes.

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FUEL CELLS - PRATT & WHITNEY AIRCRAFT

Specifications

The revised issue of the fuel cell procurement specification was reviewed. Several corrections were made to types of reliability and qualification tests required, to instrumentation, to limiting temperatures, and to system weights. S&ID submitted the revised specification to Pratt & Whitney Aircraft for final review.

A rough draft of the fuel cell radiator specification was completed.

The first 31-cell stack was operated for 43 hours at Pratt & Whitney. Firm specifications have been established.

Design

S&ID is evaluating the Pratt & Whitney conical support design.

The fuel cell system schematic was revised to incorporate the latest changes to the fuel cell powerplant and supercritical storage system.

A layout of the fuel cell radiator is nearing completion.

The preliminary radiator design is based on a total of 45 square feet of radiator area. Tubing size consistent with 30-psia-maximum pressure drop across the radiator is being used. Various configurations and locations on the service module are being investigated.

Geometry of the radiator panel, fin and tube arrangement, system weights, tube volume, and glycol capacity have been established.

The S&ID laboratory will be capable of simulating a space mission on scale-model radiators. This simulation will not include use of cryogenic reactants because of the vacuum chamber location.

The problem of a volume change when 70-percent ethylene glycol freezes is being investigated to determine the effect that freezing of coolant fluid has on the fuel cell radiators.

Gemini Fuel Cell Study

The feasibility of using the Gemini fuel cell for the Apollo missions was studied. The increased membrane performance quoted for the lunar excursion module power system has been verified by NASA to be the same

as for Gemini. The fuel cell modules are much lighter than the current Pratt & Whitney Apollo modules. However, a weight comparison of the complete systems indicates that the Gemini system, if applied to Apollo, would result in weight similar to the present system because of control and auxiliary requirements. In addition, the fuel cell schedule would be slipped if the Gemini fuel cell system had to be scaled and adapted to the Apollo mission.

INSTRUMENTATION

Various devices for measuring mass flow of fuel cell reactant gases are being studied. The feasibility of the porous plug is questioned because of the number of variables that must be monitored for accurate mass flow determination. Various companies have been contacted in connection with this problem. A thermopile flowmeter manufactured by Hastings Raydist, Inc., seems to be applicable. The 5- to 7-watt power required throughout the Apollo mission makes this type of flow measurement device questionable for continuous indication.

POWER DISTRIBUTION SYSTEM

The inverter control circuit has been revised to permit two modes of operation: one inverter supplying two ac bus structures and two inverters supplying each of the ac buses independently.

The control circuit also includes over-voltage and phase failure sensing characteristics to remove the inverter from the bus under these conditions.

Motor switches will be used rather than relay contactors for power transfer situations to conserve energy. A general specification for motor switch contractors was initiated.

Electrical load analyses have indicated a present energy requirement of 530 kilowatt hours for a 336 hour lunar mission. The average power requirement is 1578 watts. The service module propulsion engine gimbaling system presents a maximum peak load condition of 5548 watts for a period of approximately 100 milliseconds. This peak load results from the starting characteristics of the gimbal motor. After the motor has been started, the peak load resulting from actuation is approximately 5148 watts for periods up to 5 seconds.

A detailed test plan for the electrical power system for airframes 006 and 008 was completed.

Efforts to locate an accurate mass flow measurement device with a minimum power requirement and the possibility of intermittant measurement will continue.

A FORTRAN computer program will be completed for electrical load analyses.

The over-all test plan for the distribution system will be completed in detail.

Process specifications will be initiated for the checkout of the distribution system.

SEQUENCER

The breadboard for the relay sequencer of boilerplate 6 has been fabricated and functionally tested. A solid-state breadboard of the new sequencer for boilerplate 13 was fabricated, functionally tested, and demonstrated. The breadboard involves only two functions: ignition of the tower jettison motor and tower separation.

The signal converter required to accept the maximum Q signal from the Q ball on boilerplate 12 has been designed. This will be a solid state circuit and will be a part of the sequencer for boilerplate 12.

Functional diagrams have been developed for all vehicles including airframes. New functional diagrams include the ignition of the four posigrade rockets on the service module and separation and destruction of the adapter.

Design of sequencers for boilerplate 12 and 22 will be completed during the next report period.

Fabrication of the breadboards for boilerplate 12 and 22 will be started.

Packaging drawings for the solid-state sequencer for boilerplate 13, 15, 16, and 18 will be started.

Solid-state design of the airframe sequencers will be started.

The breadboard of the Q-ball signal converter will be fabricated and functionally tested.

Process specifications for boilerplate 6, 12, 22, and 23 will be completed.

A detailed test plan for the sequencer will be completed.

PYROTECHNICS

Procurement specifications have been written for the hot wire initiator, explosive bridge wire (EBW) firing unit, EBW initiator and detonator. The lot acceptance test procedures for the EBW initiators was established.

Purchase orders were placed for EBW firing units and initiators to be used in the propulsion motor development test program.

Functional tests on four firing units were begun. These units will be used in rocket motor test firings.

The system concept for the ignition of the posigrade rockets on the service module and separation and destruction of the adapter was established. These functions will be performed by the use of EBW detonation and/or initiation.

Ground rules were established for the checkout of EBW and hot wire pyrotechnic system components.

SYSTEM ANALYSIS

A preliminary electrical bonding specification was reviewed, and comments were made for incorporation into the final revision that will direct shop personnel in Apollo electrical bonding processes.

Analysis of the Apollo launch escape system schematic diagram (revision B) is continuing. The IBM 7090 simulation program devised for revision A was changed to comply with the existing system. Times of diverse variable-delay relays will be varied to determine their operating limits.

A binomial system analysis machine program has been devised to perform circuit analysis on the IBM 7090. The program has been checked out, and a description and use procedure is being prepared.

Efforts to derive the best method for interstage bonding between the escape tower and command module and between the command module and service module are continuing. The problem is to determine the means of effecting electrical conductivity and simultaneously presenting a thermal barrier.

Preliminary test reports were reviewed to determine the need for additional testing of EBW firing units to qualify them for use under present S&ID requirements.

S&ID discussed the earth landing system sequence controller requirements with Radioplane. Radioplane agreed to change the controller wiring so that it would be compatible with established S&ID wiring and shielding requirements for electro-explosive devices. It was also indicated by Radioplane that requirements were being established so that all relays in the controller would have transient suppression devices to alternate inherently produced transients.

Statistical acceptance sampling inspection philosophy and procedures regarding procurement of explosive bridge wire initiators were resolved after discussion with NASA.

A study is being conducted to determine the variation in load sharing and internal impedance for the equivalent fuel cell circuit.

At the request of NASA, a PERT network was constructed that included fuel cells, batteries, battery chargers, sequencers, ignition system, power distribution, lighting system, inverters, and umbilicals.

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REACTION CONTROL SUBSYSTEM

PROPELLANT SYSTEMS

Command Module

The helium tanks have been relocated to improve the center of gravity position. As a result, pressurization equipment panels were redesigned, lines rerouted and new line clamp provisions made.

A new value of propellant quantity requirements has tentatively been established. New tank sizes and configurations are being evaluated.

Relocation and configuration studies of the propellant system are in progress. This is in conjunction with the proposed realignment of the engines with respect to the stability axis. During the next period, a study will be initiated to determine the effects of higher g loads imposed on the propellant system because of the deletion of the impact attenuation struts.

Service Module

Design layouts of the service module deployable reaction control system (RCS) concept are nearly complete. All configurations show the propellant quantity reduced due to increased moment arm. With the increased moment arm, however, a maneuver rate of 0.7 arc-minutes per second could not be achieved in two cases of the locations studied. All proposed locations can operate within the maneuver rate of 1.2 arc-minutes per second. Engine plume thermodynamic data indicates that with an axial engine cant a satisfactory burn time may be achieved without exceeding maximum allowable skin temperatures. A more realistic plume configuration will probably reduce the heat loads on the skin and allow a longer burning time.

Component packaging in the nozzle fairing has necessitated a slight increase in frontal area which caused an increase in drag loading over the original fairing for the surface mounted engines. The actuating mechanism is being designed for module extension and support under loading of 1 g. Extension time is planned for approximately two seconds. Five service module RCS configurations, including deployable and non-deployable types, will be evaluated. Design layout of the optimum system will be completed.

Hardware

Purchase requests for the service module helium system pressure regulator have been issued. The service module helium system check valves and the fuel oxidizer systems fill-and-drain coupling specifications have been released. New specifications for the pressure regulator, check valves, and relief valve will be completed during the next report period.

Component Tests

Acceptance testing of off-the-shelf helium components showed satisfactory performance for one Vacco regulator and four Wiggins disconnects (couplings).

A test system and procedures for testing off-the-shelf reaction control propellant components is designed and fabricated. Tests such as proof pressure drop determination, leakage rate, functional test, pressure test, and others will be performed on the propellant components using water and nitrogen gas.

Phase I breadboard components are being procured for individual functional tests. The requirements for these tests have been prepared. Testing of breadboard Phase I components will continue. The command module Phase I component installation drawing will be completed.

ROCKET ENGINE

Command Module

The command module reaction control engine procurement specification is complete.

Experimental valve and thrust chamber hardware are being fabricated.

The configuration of non-fireable engines required for RCS dynamic testing has been finalized, and an assembly drawing of this configuration has been released.

Relocation of the engines about the stability axis is being complicated by equipment space allocations. Resolution of this problem appears possible by a slight change in the originally considered engine locations.

Command module engine interface requirements to support prototype design will be completed. Development test programs will be monitored to assure compatibility of thrust chamber and valve with specification interface and performance requirements.

Service Module

The service module reaction control engine fuel was changed from Aerozine-50 to monomethylhydrazine. The latter fuel offers a much lower freezing point (-62 F) than Aerozine-50, although the other properties of the two propellants are similar.

Preliminary tests of an experimental Apollo engine utilizing monomethylhydrazine indicate the steady-state specific impulse will be reduced approximately one percent.

A series of laboratory studies is being established for the inorganic coating (Durak "B" molybdenum disilicide) tentatively selected for the RCS vernier nozzle. This program is directed toward ascertainment of the effectiveness and reliability of the RCS nozzle coating under simulated Apollo operational and space environmental conditions.

SUBCONTRACTOR ACTIVITIES-MARQUARDT CORPORATION (SERVICE MODULE REACTION CONTROL ENGINE)

A preprototype test engine was delivered to AEDC during the report period. The manufacture of the prototype engine is proceeding on schedule. Testing was completed of a developmental engine. It has been shipped to Arnold Engineering Development Center for wind tunnel checkout before initiation of exhaust plume impingement testing.

Limited testing of an experimental 100 pound-thrust engine at sea level conditions indicates that the engine is capable of producing minimum impulse bits of 0.5 pound/second with acceptable repeatability.

Test data on the prototype solenoid valves show that the peak current obtained during pull-in exceeds the capabilities of the present driver circuit configuration.

Special test equipment needs were reviewed; a reduction in cost is expected. Service module engine mounting and detail design will be completed during the next report period. Service module prototype engine test program will be monitored to assure engine compatibility with mission design.

MATERIALS COMPATIBILITY

The permanent materials compatibility impact test facility is being prepared. Sample materials are ready for nitrogen tetroxide titanium testing. Simple exploratory static corrosion tests of titanium in nitrogen tetroxide are in progress.

Measurements of helium solubility in nitrogen tetroxide have been completed. Measurements of helium solubility in Aerozine-50 were begun. Long term (four week) immersion tests of titanium in nitrogen tetroxide and monomethylhydrazine solubility measurements will begin during the next report period.

BREADBOARD TEST

Fabrication of the command module breadboard is approximately 95 percent complete. Only the upper RCS engine support structure remains to be finished.

FACILITIES

Construction of the interim reaction control test facility has been approved. Construction of the interim reaction control test facility will begin and the RCS breadboard will be placed in the facility.

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SPACECRAFT ADAPTERS

FABRICATION

The elimination of steel adapters for Little Joe II launch missions was included in a master change record. Final approval of this change is pending the completion of contract change negotiations.

The adapter structure for mock-up 9 was completed, and work continues to install posigrade rockets and associated systems.

During the next period, work is scheduled to begin in assembly of the initial aluminum adapter for boilerplate 9 dynamic testing. The adapter for mock-up 9 is scheduled to be completed and mated with the service module for the 15 December inspection.

BOILERPLATES

A study was made to determine whether it would be feasible to eliminate the boilerplate insert and boilerplate adapter and substitute in their place a short 10-inch section, which would then become the boilerplate adapter.

The drawing change to boilerplate 6 is complete. It incorporates provisions for the command-module-to-adapter separation system. A three-way adjustable fitting has been designed. This part will be coupled to the adapter, to eliminate mating problems at the thrust fittings between the command module and adapter.

DESIGN AND STRUCTURES

Prints of the adapter (116 inches long) were released. These display the C-1 Apollo configurations.

A study layout was made to effect a separation by cutting the horizontal leg of the aft frame, leaving the U-channel section on the adapter wall.

The propellent-filler access doors were redesigned to eliminate one of the two rows of fasteners. This reduced the total number of fasteners from 32 to 12 per door. The adapter side-panel test drawing was redrawn and released. A new adapter drawing list and a schedule were prepared.

The door panel test specimen for the adapter was released with the "A" change which brings it into conformity with the latest structural configuration for the spacecraft adapter. In this configuration, the six longerons are eliminated, and the body loads are distributed over the entire shell.

During the next report period, all structural drawings are scheduled for release. Also, a complete layout will be made of the posigrade rocket motor and its attachment to the adapter.

SEPARATION SYSTEM

A design study was conducted in which a linear-shaped charge was used to separate the adapter from the service module.

A clearance layout was made using the extreme limit of engine-bell travel as indicated.

Phase-I testing of the separation system will consist of test panels in which the actual sizes and thicknesses of splices and skins will be utilized. The test-panel design is now 50 percent complete, and a new test schedule is being established.

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SPACECRAFT GROUND SUPPORT EQUIPMENT

FABRICATION

During the report period, general GSE effort was restricted to preplanning activities concerning the establishment of both boilerplate and spacecraft GSE requirements.

DESIGN

The water-glycol trim control unit, which was previously a portion of the water-glycol service unit, has been designed as a separate piece of GSE. The schematic for the trim control unit has been completed, and engineering work is in progress.

REQUIREMENTS

The following procurement specifications were released after a review of requirements and utilization:

Boilerplate stabilization control system bench maintenance equipment

Boilerplate SCS spacecraft system checkout group

SCS GSE equipment

An SES GSE task statement was prepared.

The specification was reviewed for the fuel cell powerplant shipping container. Preliminary checkout requirements are complete for the crew systems checkout group.

During the next period, checkout and bench-maintenance GSE requirements for the ablative nozzle engines of the command module will be established.

The SCS-GSE delivery schedule will be revised to reflect the revised Apollo missions.

MECHANICAL DESIGN

The following models have been released:

Fluid disconnect set

Support base and stand

Heat shield sling

General purpose dolly

One hundred fifty master schedule authorization forms were released on nonstandard procurement items for the Apollo program.

ELECTRICAL DESIGN

Sheet-metal layout and fabrication drawings of the test operator's console and test observer's console were completed for simulation purposes.

DESIGN STATUS

Item	Status
Launch Escape Tower Intermodule Simulator (A14-001)	Electrical analysis is 60 percent complete.
Pyrotechnic Devices Simulator Set (A14-003)	The explosive bridge wire (EBW) monitor circuit has been breadboarded and tested.
	The hot wire electrical analysis is 60 percent complete. Detail drawings of the EBW simulator package are being prepared.
Power Distribution Group (C14-027)	Analytical design of the blockhouse power console is completed.
R&D Instrumentation Bench Maintenance Equipment (C14-053)	Design analysis is completed and layouts are being prepared.
Mobile Data Recording Group (C14-089)	Electrical analysis and design is 100 percent complete. Mechanical design is 55 percent complete.

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Item	Status
Signal Conditioner Console (C14-135)	Design analysis is 85 percent complete; electrical design is 5 percent complete. Functional test procedures for this unit are being prepared.
On-Board Recorders Checkout Unit (C14-031)	Electrical analysis is 75 percent complete.
Antenna Checkout Unit (C14-032)	Electrical analysis is 85 percent complete.
Test Conductor Group (C14-019)	Electrical analysis is 85 percent complete. The silicon control rectifier lamp driver circuit has been breadboarded and qualified. The control circuit for the tape recorder (elapsed time meter) run indication has been breadboarded and qualified. The design of the meter reference device has been breadboarded and qualified. A preliminary functional test specification has been prepared for this unit.
Electrical Cable Set (C14-114)	Design analysis is 25 percent complete.
Electrical Junction Box Set (C14-025)	Design analysis is 65 percent complete.
Earth Landing Sequencer Bench Maintenance Equipment (C14-126)	Design analysis is 50 percent complete.
EBW Firing Unit, Bench Maintenance Equipment (C14-127)	Engineering analysis and schematics are complete.

Item	Status
Command Module GSE Verification Simulator (A14-029)	Electrical analysis is 5 percent complete.

CHECKOUT SYSTEMS

Self-check systems were investigated and a report describing GSE test point selection matrix was prepared.

DESIGN AND PROCUREMENT

The design specification for the water-glycol service unit (S14-052) will be completed during the next report period.

The mechanical design of the following items will be released:

Spacecraft weight and balance fixture (H14-017)

Flow skirt adapter (H14-027) and flow skirt sling (H14-029)

Launch escape system transport cradle (H14-083)

Heat shield weight and balance set (H14-087)

Service module and adapter weight and balance set (H14-9059)

Procurement specifications will be released for the following items:

Vacuum cleaner (A14-035)

Helium booster unit (S14-022)

Liquid hydrogen transfer unit (S14-026)

Liquid oxygen transfer unit (S14-032)

The following engineering requirement reports for test facilities will be released:

SID 62-824-Static Firing Facility - AMR

SID 62-1059-Pad 34 - AMR

SID 62-1084-Preparation and Checkout Interim Facility - AMR

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GROUND OPERATIONAL SUPPORT SYSTEM INTERFACE

A funding report for the space communication and tracking laboratory (SCATLAB) implementation plan has been prepared and is being reviewed.

Fulfillment of the SCATLAB schedule, including refurbishment of two 28-foot antennas, is dependent on early resolution of the funding problem.

A computer program is being run to determine the coverage that can be expected from the deep-space instrumentation facility stations within a 30,000-nautical-mile limit.

Operations analysis efforts have been centered on establishing parameters for the lunar mission critical phases. Launch azimuth and multiple parking orbit coverage are being considered based on the number of ground operational support system (GOSS) stations required. The nature of spacecraft checkout procedures is also under study.

A preliminary draft of the Apollo back-scatter measurement work statement has been reviewed.

During the next period, the final draft of the back-scatter measurement work statement will be reviewed, and the subcontractor will be selected.

The coverage, information, and display requirements of lunar mission phases will continue to be studied.

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SIMULATORS AND SIMULATION

EVALUATORS AND SIMULATORS

Evaluator 1 has been reworked for Study 6.1 (orbit attitude control). Analog computers for this evaluator have been received.

Evaluator 2 has been fabricated.

Rough drafts of revised definitions and objectives for simulators 1 and 2 have been completed.

VISUAL SIMULATION

A four-degree-of-freedom visual display concept was developed for analyzer I. Parts have been selected, and purchase requests are being processed.

Data on all visual display systems in use and under development were collected and studied, completing the Apollo display.

FACILITIES

A detail floor plan, an equipment list, by, and outline drawings of a proposed simulation facility have been completed.

COMPUTER REQUIREMENTS

Initial results of a feasibility study for real-time simulation indicate that the IBM 7090 is unsatisfactory for such a program.

A number of digital computers have been investigated for inclusion in a real-time hybrid simulation complex.

SIMULATION STUDIES

Study 6.1 (attitude control dynamics) is undergoing static problem check.

Study 6.2 (orbital transition dynamics) is completed.

Study 6.4 (rendezvous docking) runs are being obtained at the NAA Columbus Division.

Study Series 4 has been designed, and analytical tasks have been accomplished.

Study Series 6 has been redirected toward the rendezvous flight phase, and new milestones have been established.

New computer equipment for Study Series 6 will be checked out.

Equipment description for the proposed simulation facility will be completed.

Specifications for the visual display system will be finished.

Evaluator 1 will be reworked. Extra controls and displays for a rendezvous study will be installed.

Control and displays will be installed in evaluator 2 so that Study Series 4 (full space mission and system evaluation) can be initiated.

Revisions to the spacecraft simulation program plan will be started. The revised plan will incorporate the new study schedule and will reflect the deletion of evaluator 3 and 4 and simulator 3.

The IBM 7090 feasibility study will continue. A presentation will be made concerning the desirability of other computers for use in real-time hybrid simulation.

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TRAINING AND TRAINERS

The Apollo Training Plan (SID 62-162), 30 September revision, was submitted to NASA.

Lesson guides for the three-hour, six-hour and three-day Apollo familiarization briefing courses were completed. These courses are being programmed on a regularly scheduled basis.

Preparation of the training data control system for Apollo documentation is nearing completion.

The first draft of the flight crew operations division objectives has been completed.

A complete package of "Units of Training" for astronauts is being prepared for presentation to NASA.

The ground crew performance criteria is being revised to give the training department an official listing of flight controller tasks. Course outlines for the flight controllers course are in preparation.

The mathematical outlines, including new visual simulation and rendezvous data, for the trainer-mission simulator are complete. Procurement specifications for the trainer-mission simulator will be released during the next period.

The design development of the navigation and trajectory control trainers, the orbital and rendezvous trainers, and the earth launch and reentry trainers is on schedule. Preliminary structural design of the command module for these trainers has been initiated.

Detailed briefing charts on the trainers were prepared and have been presented to NASA.

Computer procurement specifications for part-task trainers will be released.

Work will begin to develop a method for automatic programming and operation of the simulation complex.

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INSTRUMENTATION

CONTROLS AND DISPLAYS

The status of controls and displays activities is presented in the following:

Item	Status
Rearrangement of electronic equipment in the main display and side consoles	Complete
Preliminary launch countdown control study	Complete
Simulated integrated display system	Complete and installed on the display console breadboard
Drawings for back-up entry display packaging mock-up	Complete and released

A controls and display mock-up will be constructed during the next report period. A preliminary main display console installation layout will be prepared that will define structures, coldplates, wire channels, and display instrument locations.

TAPE RECORDER ENCLOSURES

The reinforced fiberglass enclosures is complete. All units were tested and evaluated. Design criteria were established as a result.

An improved design is now being fabricated. Completion is scheduled during the next report period.

OPERATIONAL MEASUREMENTS

As a result of the integration of measurement systems with in-flight test systems, GSE, telemetry and displays, the following decisions were made:

1. A signal-distribution panel will be used instead of a patch panel. This will permit signal routing by fixed wiring.

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2. Signal-conditioning equipment will be located in the service module.

3. In the command module, 77 signal conditioners will be required; in the service module, 45 will be required.

4. A signal input-impedance requirement of greater than one megohm has been established.

5. A maximum induced measurement-system noise at the distribution panel shall not exceed 5 millivolts peak-to-peak.

An in-flight test system (IFTS) measurement list will be prepared during the next report period.

PROPULSION TEST SPACECRAFT (AIRFRAME-001)

Analyses of measurement systems for acoustics, vibration, pressures, flow, strain, and temperature (probes and surface elements) are complete.

Instrumentation measurement systems design criteria for the propulsion development test stands at White Sands have been completed.

A method has been devised for the calibration of measurement systems in the test stands. This method is included in the design criteria manual.

LEAK DETECTION

Studies have been initiated to determine the feasibility of monitoring liquid fuel leakage in a space environment.

RESEARCH AND DEVELOPMENT INSTRUMENTATION

Measurement requirements are in final form for the launch escape tower and motor static-firing test program, ATR 502.

Instrumentation measurement lists specifying equipment and location for boilerplates 13 and 15 are complete.

Reports scheduled for completion during the next report period are Memorandum Report on Equipment Connector Minimization Analysis, Automatic Processed Wire Listing for EMI Reduction, and EMI Radiation Studies.

The sensors for each firmly established measurement requirement will be selected and evaluated.

A calibration concept will be established that will, in some cases, include in-flight calibration.

DUMMY INSTRUMENTATION

An instrumentation system designed for use with anthropomorphic dummies for the drop test programs is nearing completion. The system consists of transducers, power supply, a recorder installed within each dummy, and various transducers located external to the dummy.

The recorder will use 1-inch tape and will have a capability for 35 data channels. The data channels will consist of nine tracks of wide-band data, two direct-record tracks, and three FM multiplexed tracks. There will be eight subcarrier oscillators per track. The recorder will record for a maximum of 15 minutes.

Installation layout drawings for the three cavities of the dummy (skull, chest, and pelvic) have been prepared and transmitted to the dummy manufacturer. Identical installation requirements for 10, 50, and 90 percentile dummies, facilitate interchangeability.

Equipment installed in the skull cavity will be attached to the removable portion of the skull. The recorder will be mounted to the door of the chest cavity. The batteries will be located in the pelvic cavity.

During the next report period, preparation of procedures required for checkout and calibration of dummy instrumentation will be initiated. Detailed transducer locations within the spacecraft will be determined.

RADIATION INSTRUMENTATION

A plan of action and an associated schedule for the development and procurement of a radiation detection and monitoring system have been prepared. The plan of action will be submitted to NASA for review and approval.

During the next report period, detailed specifications for NASA-furnished biological dosimeters will be obtained. A report will be issued concerning the various methods for the determination of directional components of space radiation.

SUBCONTRACTOR RELATIONS

As a result of coordination meeting with Aerojet General, it was agreed that Aerojet General would provide the engine sensors and that S&ID would provide the signal conditioners for them.

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In coordination with subcontractors, it was established that subcontractors would provide all the sensors for their respective subsystems, subject to S&ID approval. The only exception is that S&ID will furnish sensors for the propulsion subsystem.

During the next report period purchase requests will be released for the recorder and transducers to be used for the dummies, and the IFTS procurement specification will be released.

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SPACECRAFT TEST OPERATIONS - TULLAHOMA

Facility requirements are being reviewed to determine alternate environmental chambers that might be used in place of the Mark I at AEDC.

The detailed PERT network has been revised to reflect the environmental test programming in accordance with the 12 October 1962 Master Development Schedule.

During the next period, the major effort will continue toward coordination of the detailed test plan, facility, and support documents.

Engineering and ATO will establish a proof program definition as agreed to by NASA to define the program/facility scope in support of Airframe 006 and 011 flights. Results will be presented to NASA during the next period.

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SPACECRAFT TEST OPERATIONS - DOWNEY

Detailed requirements for Building 6A test facilities have been established.

Coordination with Apollo Engineering and Facilities groups has resulted in a decision that there will be no immediate requirement for a large screen room (located in Building 6A) for integrated systems radio frequency interference testing.

The GSE requirements for the airframe 006 testing program have been reviewed and issued.

A working group has been established that includes members from the test integration group and responsible design groups. This group will establish preliminary handling and installation procedures for the spacecraft systems in boilerplate 14.

Preliminary checkout procedures have been reviewed for the antenna systems, transducers, power distribution system, and integrated systems of the house spacecraft.

The S&ID source selection board has selected a vendor for the Apollo data facility, and corporate level approval has been obtained.

Detail test planning for GSE facility checkout for Building 6A and the interim test facility will continue during the next period.

The procurement specification for the telemeter recording and checkout facility will be issued.

The spacecraft prelaunch automatic checkout equipment (SPACE) concept will be reviewed for its effect on the house spacecraft operations.

The preliminary test preparation detail time phasing schedule for boilerplate 6 will be prepared.

Study of the interim facility test area for the test preparation activities will be continued.

Writing of the preliminary detail checkout procedures for boilerplate 6 will be initiated.

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PRELAUNCH AND LAUNCH OPERATIONS - AMR

The program requirements document (PRD) was completed and will be forwarded to NASA.

PERT networks for boilerplates 9, 15, 16, and 18 and airframes 009 and 011 were modified to reflect the 12 October Master Development Schedule and test objective changes.

A detailed checkout procedure for mating and demating the escape tower from the command module was prepared and submitted for approval. This document is applicable to boilerplate 13; however, with minor modification, this procedure will apply to all vehicles.

Time phasing test schedules for AMR instrumentation were prepared and informally released to the NAA-AMR field office.

The instrumentation GSE scheduled for use at the WSMR operation has been reviewed for application to AMR research and development operations. The required modifications will be discussed with NASA-MSC.

The revised AMR Apollo Checkout Flow (IOL ATO 62-467) was presented to NASA-POD and MSC representatives at Downey during the report period. This revision included the use of separate facilities for the reaction control system (RCS), environmental control system, (ECS), and static firing checkout as requested by NASA-POD.

A revised interim facility layout was prepared for checkout of boilerplate articles.

The Apollo test and operations field office at AMR was established with the assignment of three permanent engineers.

During the next period, rework of the boilerplate 13 detailed test plan to the mission directive format is being prepared and should be completed by approximately 15 November 1962.

Several detailed test procedures for boilerplate 13 are in work. These procedures will be released as soon as possible.

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Efforts are continuing to further define facilities requirements. Detailed studies are being conducted to determine the need for cryogenic gases in the vacuum chamber.

The detail instrumentation operations and tests for ARM research and development operations will be reviewed and published.

The instrumentation operational procedures to be utilized at the AMR for the boilerplate operations will be determined.

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SPACECRAFT TEST OPERATIONS - WSMR

Resolution was obtained between NASA and S&ID on the GSE concept. A set of GSE will be used at WSMR. The checkout equipment will be located in the transfer room and the launch equipment will be located in the block-house. Two sets of GSE will also be provided for Downey. One set will be used in the manufacturing area, and the other set will be used in the test preparation area located in Building 6A.

The WSMR mission abort facilities requirements were finalized and submitted to NASA for use by the Army Corps of Engineers to implement the construction contract.

A preliminary draft of the Propulsion Test Plan (Section 4, Volume III, SID 62-109) was completed. Two copies were forwarded to NASA by TWX to support facilities criteria evaluation. Detailed plans were included for the basic systems evaluation test phase only. Detailed qualification-reliability test plans were not available for this draft.

The Apollo test and operations and facilities personnel met with NASA at WSMR in September to discuss the propulsion test facility. NASA/WSMR personnel agreed with the facilities plans presented by S&ID.

The mission directive for boilerplate 12 will be submitted to NASA for approval and formal release during the next period.

The preparation of the detail checkout procedures for boilerplate 6 will be initiated.

The Propulsion Test Plan will be prepared for formal submittal as part of the General Test Plan, SID 62-109, on 30 December 1962.

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SPACECRAFT RELIABILITY

MSC APPROVAL OF RELIABILITY DOCUMENTS

NASA reliability personnel verbally approved the reliability program plan (SID 62-203) and the qualification-reliability test plan (SID 62-204). Minor revisions were discussed, and a letter containing a formal approval should be received shortly. The next revision to these documents is scheduled for 1 January 1963.

TELECOMMUNICATION SYSTEM COST REDUCTION STUDY

A reliability evaluation was completed on the proposed changes for the telecommunications subsystem. Two changes were evaluated: (1) elimination of one deep space information facility transponder and one VHF-AM transceiver; and (2) elimination of one set of data storage equipment, one TV camera and the television monitor. Retention of the present redundant DSIF transponder and VHF-AM transceiver would provide a significant reduction in failure rate. The deletion of the data storage, TV camera, and TV monitor would result in a decrease in system performance with a slight improvement in the failure rate due to simplification of equipment.

COMMAND AND SERVICE MODULE WEIGHT REDUCTION STUDY

A preliminary study to determine the effects on reliability by reducing command module and service module weight was completed. A reduction in the number of fuel cells and inverters plus the elimination of spares from the stabilization and control system (SCS) would have the most significant influence on reliability. Incorporation of these changes would result in reduction of the required mission success reliability from 96 percent to 80 percent and crew safety reliability from 99.9 percent to 99.2 percent.

ELECTRICAL POWER SUBSYSTEM

A reliability apportionment for the fuel-cell filter-valve assembly was completed. Components, originally located in the dual reactant supply manifold, have been incorporated in this assembly. The design change does not alter the reliability of the overall system, but it does eliminate the possibility of a catastrophic failure.

ELECTRONIC SUBSYSTEMS

A detailed reliability study involving parts count, failure rates, mission time, and reliability has been completed for each piece of equipment in the guidance and navigation, stabilization and control, telecommunications, and data and instrumentation electronic subsystems. The results of this study will be used during the parts improvement program to define those Apollo components on which emphasis will be placed and to determine the requirements for component reliability growth.

COMMAND MODULE REACTION CONTROL SYSTEM

A reliability engineering analysis for six configurations of the command module RCS was completed. The configurations evaluated were original dual, original triple, improved dual, improved triple, dual system with a common pressurization subsystem, and a triple system with a common pressurization subsystem. Analysis indicated the improved dual system to be the most reliable of the six configurations. Additional studies are in progress presupposing best available components or minimum required improvements in the most reliable system.

POSIGRADE ROCKET MOTOR SYSTEM

A reliability engineering analysis for posigrade rocket motor configurations of two, four, and eight motors was completed. These configurations were considered for separation of the command and service module during high altitude abort. The four motor configuration was selected as providing the least degradation to spacecraft reliability.

MONTE CARLO RELIABILITY MODEL

The Monte Carlo mathematical model for the Apollo spacecraft was revised to permit simulation of abort modes of operation. All data inputs are available for computer analysis. The first run will involved (1) 20,000 mission simulations to produce mission reliability within one-half of one percent, (2) the number of failures for each phase of the mission, (3) the number of times each component results in a mission failure (for primary and alternate models) and (4) the statistical confidence associated with the results.

DATA OPERATIONS

A chronological data systems development and accomplishment report for the months of June, July, and August was prepared to highlight the data functional operations in support of the Apollo program.

Procedures in progress and completed during the month include the non-conformance reporting system, a supplier quality history, identification and traceability, and operating time and critical parts reports.

Interservice Data Exchange Program (IDEP) reports have been distributed. An index of approximately 5200 reports was distributed to personnel concerned with the IDEP system.

HARDWARE UTILIZATION LIST

Apollo reliability engineering has received all Apollo spacecraft hardware requirements to provide a new estimate of qualification-reliability test articles required to demonstrate reliability. Each test program (development, boilerplate, and spacecraft) was evaluated to determine the amount of useful data that will be obtained for reliability demonstration. A comparison between these data and the number of hours required to demonstrate reliability was used to develop a new hardware utilization list.

ANALYSES AND TESTS

During the next period, a reliability cost study will be conducted to define the costs required to achieve various probabilities of success, up to and including current requirements. A crew safety analysis will be conducted to perform complete failure mode analysis on all systems, including launch vehicles. A qualification-reliability test will be conducted to review and define the detailed requirements for qualification and reliability demonstration of critical functions at the system level. Statistical analysis will develop a mathematical model for demonstrating reliability at a high confidence level using small sample sizes.

QUALITY CONTROL

Specifications

A quality control specification, General Requirements for Supplier's Quality Control System, has been rewritten to incorporate the requirements of NCP 200-3 and applicable sections of NCP 200-2. The specification has been submitted to NASA representatives for review prior to release and implementation.

Identification and Traceability

The identification and traceability system has been fully implemented in the manufacturing area by means of the fabrication assembly inspection record (FAIR) system. Quality control is now assigning lot or serial numbers to all items not appearing on the exempt parts list. Quality

engineering, in coordination with reliability, is analyzing all drawings for traceability requirements and compiling a list of traceability exempt items which will be submitted to NASA for inclusion in the exempt parts list.

Inspection and Test Planning

The FAIR system has replaced the inspection and test instruction sheet as the controlling inspection document. Inspection and test instructions are now being incorporated in the FAIR book.

Quality Control Laboratory

The materials evaluation group assembled a distillation apparatus to determine the amount of nitrogen in titanium. This in-plant capability has effectively reduced by half the number of samples formerly sent out for testing. A method of analyzing for oxygen is being devised using vacuum fusion and gas chromate graphic techniques. This will eliminate the necessity of sending titanium samples out for this type of analysis.

A testing chamber has been installed in the laboratory for material testing in space vacuum. The test chamber is 1 inch in diameter by 4 inches in length and is capable of producing a vacuum with an absolute pressure of 1×10^{-10} mm Hg.

Two lots of extruded titanium tubing (gAl-4V Alloy) have been submitted to the laboratory for acceptance testing. The first contained five pieces. Of these, four were accepted by the laboratory. The fifth was withheld for materials review action due to low elongation values. The surface of the samples submitted to the laboratory showed no evidence of cracks or tears; the microstructure, although directional, was generally good for an extruded product. The second lot of material was unsatisfactory.

The quality control laboratory ran acceptance tests on Apollo fusion welding equipment and positioning equipment. The weld equipment utilizes a weld skate that travels the seam electronically and fusion welds by the TIG ac-dc and MIG processes. The items of weld equipment were approved for immediate shipment. A huge circumferential positioning machine to hold the Apollo command module for welding and machining was inspected. Two heavy-duty trunnion-type positioners also scheduled for checkout and shipment at a later date were inspected as far as completion would allow. An electron-beam welding machine was also inspected, tested, and approved for immediate shipment.

Training and Certification

A new instruction course was introduced during the report period which provides training for manufacturing and inspection personnel involved in the FAIR system.

Supplier Evaluations

Ten manufacturers were surveyed for adequacy of their quality control departments and facilities. Products involved consisted of ground air cooling carts along with miscellaneous electronic equipment. Seven firms were approved, two were disapproved, and the rating was withheld on the remaining firm.

Quality Control Representatives at Subcontractors

The first of the semi-annual seminars with the resident quality control representatives is scheduled to be held at Downey during the next period.

Procurement Planning

During the report period, 1184 purchase orders were reviewed to assure inclusion of adequate quality control requirements.

Receiving Inspection Planning

The receiving inspection planning group is developing inspection and test procedures for use by receiving inspection. Approximately sixty procedures were released during the report period.

Product Inspection

Command module boilerplate 1 has undergone three water drops since acceptance. Test results were satisfactory; however, the heat shield was broken on the third drop. This assembly is being replaced, and the unit is being readied for subsequent land drops.

Quality Evaluation and Audit

During this reporting period, 23 performance audits consisting of 404 observations were conducted. Action was initiated on 16 items. Action was completed on 9 items, with remedial action in progress on the remainder. Eleven reaudits were completed in previously discrepant areas. The reaudits revealed that all previous deficiencies had been corrected. Quality control laboratory evaluation of 15 parts was completed with satisfactory results. All parts evaluated were returned to stock.

Material Review

A quality assurance operating procedure entitled "Nonconformance Reporting System" has been published. The procedure was developed for NASA programs and establishes a nonconformance reporting system by outlining the requirements and responsibilities of quality assurance.

A quality assurance operating procedure covering material review organization, authority, and disposition has been written. This procedure has been developed specifically for NASA contracts.

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FACILITIES

DOWNEY PLANT AREA LAYOUT AND PLANNING

Apollo flight technology has begun occupancy of the mezzanine of building 1. This group will be totally consolidated when the planned evacuation of GAM-77 logistics takes place during November.

The Apollo program control room was expanded to its permanent configuration. The internal panel display arrangement will occur when total requirements are determined.

A program will begin early in November to consolidate engineering groups to conform to the new Apollo engineering structure. These moves will be completed in January, 1963, with approximately 50 percent completion in November 1962.

A rearrangement schedule of Apollo office areas was published during the report period. The schedule was based on current area availability dates released by general facilities.

Most of the program management groups will be rearranged and consolidated in Zone 15, Building 1, during November.

SUBCONTRACTOR COORDINATION

Approval has been received from NASA for the Avco facility appendix in the amount of 1.2 million dollars. Approval was also received for Avco to screen DOD industrial reserves.

Approval has been received from NASA to amend the Pratt & Whitney supply contract to permit acquisition of a vibration table and random console at a cost of $170,000. This method of acquisition is authorized on a no-fee cost-only basis. Cost and accountability of the equipment are to be transferred to the Pratt & Whitney facility contract.

The Beech Aircraft and Collins Radio Facilities appendices and the remainder of the Pratt & Whitney appendix will be approved during the next period.

The Apollo manufacturing layout has been updated to include all latest information on tooling and equipment.

Apollo trainer manufacturing is tentatively being planned for Building 1. Block-outs are being finalized and layouts will be expedited when block-outs are approved.

MANUFACTURING SUPPORT

The finalized area assignments for the occupation of the planned new space systems development facility were completed on 15 October. The building now features a layout with extreme utility and flexibility for future expansion.

Apollo facilities management met with NASA at Houston during the report period to provide additional information for the advanced approval of approximately $200,000 of facility contract equipment. NASA approval to fund these items is urgently required due to long lead time involved in procurement.

An addition to Building 4, which is planned for the formal mock-up review, was completed on schedule.

A technical review of the proposed space systems development facility by NASA is scheduled.

FACILITIES PROJECTS

Bids were received during the report period for exploratory water drilling at the propulsion systems development facility, Las Cruces, New Mexico.

Phase III design drawings and specifications for the parking facility at Downey were approved by NASA on 26 October. All facilities actions are now complete. Construction is scheduled to start during the next period.

Changes in the systems integration and checkout facility due to the lunar escape module concept have been incorporated into the architectural-engineering design. Design work on the front section of the facility has been stopped pending NASA approval on changes required to support spacecraft prelaunch automatic checkout equipment concept.

Contracts will be let early in November for pre-design architectural-engineering studies and exploratory water well drilling at Las Cruces facility.

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Formal approval by NASA of the impact test and plaster master facilities at Downey is expected shortly.

APOLLO FACILITIES STAFF

The Apollo facilities plan, a contractual obligation, was submitted to NASA 30 September. Copies have been distributed to Apollo management and facilities supervision.

A PERT display board, similar to the Apollo facilities PERT board, will soon be installed at NASA, Houston. This will permit joint monitoring of facilities progress between NASA and S&ID.

GENERAL

To cope with the rapid growth in task assignments and personnel, a revised organization structure was initiated early in October by Apollo facilities management.

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DOCUMENTATION

SID 62-702-1, Support Plan, and SID 62-702-2, Maintenance Plan, 30 September 1962 revisions, were delivered to NASA.

Support analysis of boilerplate 19 has been completed and distributed.

Support analysis for paint, oil, and lubricants requirements for White Sands Missile Range (WSMR) has been completed.

The boilerplate 6 support analysis will be completed during the next period. In addition, a daily record will be maintained by each analyst on the component breakdown which will reflect recommended spares.

An advanced copy of Contract Change Authorization 5, NAS9-150, Statement of Work, Part 4, Appendix 4-C, was received. The impact upon the Apollo support manual program will be identified in detail upon the initiation of a plan of action for the CCA.

The requirement for revision of documentation requirements for project Apollo suppliers was satisfied during the reporting period. The revision specifically identified all support manual requirements and delivery dates to be imposed on major subcontractors and suppliers.

A scheduled meeting with NASA personnel was cancelled by NASA. S&ID recommends that a meeting with cognizant NASA personnel to discuss support manuals be held at the earliest opportunity.

The following S&ID documents were published during the month of October.

SID No.	Title
62-102	Apollo Manufacturing Plan
62-153	Apollo Facilities Plan
62-162	Apollo Training Plan
62-170-3	Apollo Wind Tunnel Program Report
62-109-1	Apollo Test Plan
62-109-2	Apollo Test Plan
62-109-3	Apollo Test Plan

SID No.	Title
62-384-14	Apollo Drawing List
62-384-15	Apollo Drawing List
62-400-3	Quarterly Progress Report
62-566-9	Still Photography Report
62-566-10	Still Photography Report
62-566-11	Still Photography Report
62-566-12	Still Photography Report
62-600	Apollo Data Submittal Document
62-669	Test & Model Information for Wind Tunnel Tests in the Apollo in the Nacal Wind Tunnel
62-670	Test & Model Information for Wind Tunnel Tests of a 0.02 Seal Force Model in the Apollo NAA Tri Sonic Wind Tunnel
62-700-1	Apollo General Requirements Specification
62-700-2	Apollo General Requirements Specification
62-700-3	Apollo General Requirements Specification
62-702	Apollo Maintenance Concepts
62-702-1	Apollo Maintenance Plan
62-702-2	Apollo Support Plan
62-703-1	Apollo GFP, GFAE Requirements
62-703-2	Apollo GFP, GFAE Requirements
62-784	Qualification Status List
62-1000	Apollo Navigation & Guidance Interface Requirements Specification
62-1001	Apollo R&D Flight Instrumentation Interface Requirements Specification
62-1002	Apollo Scientific Instrumentation Interface Requirements Specification
62-1003	Apollo NASA Furnished Crew Equipment Interface Requirements Specification
62-1004	Non NAA Ground Support Equipment

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SID No.	Title
62-1005	Goss Requirements Specification
62-1006-1	Saturn Launch Vehicle Interface Requirements Specification
62-1006-2	Little Joe II Launch Vehicle Interface Requirements Specification
62-1014-1	Apollo Hardware Definitions
62-1014-2	Apollo Hardware Definitions
62-1014-3	Apollo Hardware Definitions
62-1133	Pretest Report for the 0.040 - Scale Apollo Heat Transfer & Pressure Model
62-1151	Transient Pressures Measured on the 0.055 Scale Apollo Pressure Model in NAA Tri Sonic Wind Tunnel
62-1195-1	Apollo Cost Proposal
62-1195-2	Apollo Cost Proposal
62-1195-3	Apollo Cost Proposal

APPENDIX A

MEETINGS AND TRIPS

Table A-1. S&ID Apollo Meetings and Trips, October, 1962

Subject	Location	Date	S&ID Representative	Organization
Parachute drop tests discussion	Houston, Texas	1 October	Young, Lowry	S&ID, NASA
Crew safety meeting	Houston, Texas	1 October	Garton	S&ID, NASA
Flight technology meeting	Houston, Texas	1-2 October	Fouts, Dudek, Bornermann, Wiltse	S&ID, NASA
Mission simulator training briefing	Houston, Texas	1-4 October	Pollard, Neff, Smith, Nave, Blanchard, McIntyre	S&ID, NASA
Stabilization and control review	Minneapolis, Minnesota	1-4 October	Lu, Robins	S&ID, Minneapolis-Honeywell
Technical progress discussion	Houston, Texas, Minneapolis, Minnesota	1-4 October	Osbon	S&ID, NASA, Minneapolis-Honeywell
Implementation discussion	Houston, Texas	1-5 October	Weido, Regan, Smith	S&ID, NASA
Facility requirements coordination	White Sands, New Mexico	1-5 October	Kennedy	S&ID, NASA
Temporary resident engineer	East Hartford, Connecticut	1-7 October	Nash	S&ID, Pratt & Whitney
GSE conference GSE design and review	Minneapolis, Minnesota	1-10 October	Fritzinger, Gibson	S&ID, Minneapolis-Honeywell
Docking simulation coordination	Columbus, Ohio	1-11 October	Krimgold, Akita, Oglevie	S&ID, NAA-Columbus
Wind tunnel tests	Mountain View, California	1-12 October	Davis, Rashidian, Hill, Svendson	S&ID, Ames
Wind tunnel tests	Hampton, Virginia	1-26 October	Large, Lundy	S&ID, Langley Research Center
Primary structure and navigation base installation meeting	Downey, California	2 October	Todd	S&ID, MIT
Communications control and display layout coordination	Downey, California	2 October	Graham	S&ID, Collins Radio
Biweekly power systems meeting	Houston, Texas	2-3 October	Field, Simkin, Bonjak, Merkoff	S&ID, NASA
Spares requirements	Van Nuys, California Los Angeles, California	3 October	Madison Guenshe, Harris, Warriner	S&ID, Marquardt Corporation S&ID, Northrup-Ventura
Guidance analysis panel meeting	Houston, Texas	3-4 October	Cole, Louis, Meyers, Overman	S&ID, NASA
Biweekly mechanical systems meeting	Houston, Texas	3-4 October	Johnson, Necker, Burrell, Nerhoff, Dupaquier	S&ID, NASA

Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
Environmental proof spacecraft review	Houston, Texas	3-4 October	Williamson, Overman	S&ID, NASA
Environment test and facilities	Houston, Texas	3-4 October	Alexander	S&ID, NASA
Appendix A review	Las Cruces, New Mexico	4 October	Bailey	S&ID, NASA
Rendezvous sensors discussion	Cambridge, Massachusetts	4-5 October	Hogan, Walker, Turnage	S&ID, MIT
Bioinstrumentation meeting	Chicago, Illinois	4-8 October	Steinmetz	S&ID, AIEE, ISA
Hydrological and aerial survey	Houston, Texas	5 October	Mundy	S&ID, NASA
Preliminary review	Azusa, California	5 October	Nelson, Benner, Sherman, Beck, Oppenheim, Flynn	S&ID, Aerojet-General
Pretest conference	Tullahoma, Tennessee	6-9 October	Biss, Clemmer	S&ID, AEDC
Unified communication systems meeting	Houston, Texas	7-8 October	Pope, Dwinell	S&ID, NASA
Support telecommunications meeting	Houston, Texas	7-10 October	Tarr, Atlas	S&ID, NASA
Temporary technical representative	Hartford, Connecticut	7-11 October	Anderson	S&ID, Pratt & Whitney
Crew systems meeting	Houston, Texas	7-11 October	DeWitt	S&ID, NASA
Instrumentation system coordination	Houston, Texas	7-12 October	Barmore, Thurman, Himmelberg	S&ID, NASA
Computer simulation coordination	Columbus, Ohio	7-13 October	Dunage	S&ID, NAA-Columbus
Parachute drop tests preparation	El Centro, California	8-10 October	Young, Waudy, Lowry, Weaver	S&ID, USN
Electrical sub-panel operations	AMR	8-11 October	Ciglar, Lassiter, Pumphery, Randall, Siwolop	S&ID, NASA
Docking simulation meeting	Columbus, Ohio	8-20 October	Akita, Oglevie	S&ID, NAA-Columbus

Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
Temporary engineering representative	Cedar Rapids, Iowa	8 October 23 February	Berkemeyer	S&ID, Collins
Biweekly electrical systems meeting	Houston, Texas	9 October	Dwinell, Dorrell, Atlas	S&ID, NASA
Heat shield and interface briefing	Houston, Texas	9-10 October	Vucelic	S&ID, NASA
Biweekly GSE meeting	Houston, Texas	9-10 October	Russell, Siwolof, Randall, Artz	S&ID, NASA
Systems trainers conference	Houston, Texas	9-11 October	Steisslinger	S&ID, NASA
Quarterly briefing	Houston, Texas	9-11 October	Sherman	S&ID, NASA
Guidance and space flight meeting	Huntsville, Alabama	9-12 October	Cooper	S&ID, NASA
Test support meeting	Hampton, Virginia	9-13 October	McNary	S&ID, Langley Research Center
Vehicle integration coordination	Houston, Texas	9-26 October	Pope	S&ID, NASA
Quarterly status review	Houston, Texas	10-12 October	Wells, Benner, McCarthy, Ryker	S&ID, NASA
Engineering survey coordination	Houston, Texas Las Cruces, New Mexico	10-12 October	Potter, Walker	S&ID, NASA
Flames and rocket exhaust conference	Palm Springs, California	10-12 October	Piesik	S&ID, NASA
Technical and interchange discussion and heat shield meeting	Wilmington, Massachusetts	10-19 October	Stone, King, Morant, Confer, Hanifin, Bemis, Gershun, Hurthun, Mathews, Chadbourne	S&ID, Avco
Life systems meeting	Columbus, Ohio	10-24 October	Patton, Canby, Donaldson	S&ID, NAA-Columbus
Cryogenic storage system discussion	Boulder, Colorado	12-13 October	Haglund, Axel	S&ID, Beech Aircraft
Studies discussion	Brooks, Texas	12-21 October	Wells	S&ID, NASA
Guidance lab meeting	Cambridge, Massachusetts	13-16 October	McCarthy, Mahoney, Berry	S&ID, MIT

Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
Visual simulation display	Sacramento, California Merced, California	14-17 October	Cave	S&ID, USAF
Temporary engineering representative	Hartford, Conneticut	14-18 October	Cooke	S&ID, Pratt & Whitney
Space phenomena measurements meeting	Detroit, Michigan	14-18 October	Clark	Symposium
Simulation coordination studies	Columbus, Ohio	14-19 October	Porter	S&ID, NAA-Columbus
Flight table demonstration	Menlo Park, California Sunnyvale, California	15-16 October	Cauble	S&ID, Carco California Technical Industries, Lockheed Aircraft Corporation
Biweekly flight technology meeting	Houston, Texas	15-16 October	Lundgren, Gershun, Copeland, Jones, Percy	S&ID, NASA
Crew safety meeting	Houston, Texas	15-16 October	Garton, Jacobson, Johnson	S&ID, NASA
Parachute drop test operation	El Centro, California	15-18 October	Young	S&ID, USN
Monthly coordination meeting	Cedar Rapids, Iowa	15-18 October	Downs	S&ID, Collins
Coordination conference	Huntsville, Alabama	15-19 October	Grycel, Henery, Wright, White, Baum, Johnson	S&ID, NASA
Predesign studies coordination	Las Cruces, New Mexico	15-19 October	Doyle	S&ID, NASA
Wind tunnel tests	Moffett Field, California	15-20 October	Davis, Gielow	S&ID, Ames
Wind tunnel tests	Buffalo, New York	15-30 October	Clemmer	S&ID, Cornell
Trade board meeting	Washington, D. C.	16-17 October	Berry	S&ID, Washington Trade Board
Biweekly power systems meetings	Houston, Texas Boulder, Colorado	16-18 October	Bouman, Copeland, Percy, Barnett	S&ID, NASA, Beech Aircraft
GSE coordination	Houston, Texas	16-19 October	Gobhart, Akers, Lindley, Triman	S&ID, NASA

Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
Visual simulation display	Dallas, Texas Fort Worth, Texas Oklahoma City, Oklahoma	16-20 October	Nave	S&ID, USAF, FAA Standardization Center
Guidance analysis panel meeting	Houston, Texas	17-18 October	Johnson, Louie, Timothy	S&ID, NASA
Biweekly mechanical systems meeting	Houston, Texas	17-18 October	Necker, Schmidt, Large, Lowry	S&ID, NASA
Design review meeting	Downey, California	17-18 October	Feltz	S&ID, NASA
Propellant rocket static test panel	Sunnyvale, California	17-19 October	Bellamy	S&ID, United Technology Corporation
Facilities review	Boulder, Colorado	17-19 October	Carter	S&ID, Beech Aircraft
Subcontract discussion	Cedar Rapids, Iowa	17-19 October	Pope, Osbon	S&ID, Collins
Progress evaluation and tooling coordination	Middleton, Ohio	17-19 October	Perry,	S&ID, Aeronca
GSE checkout meeting	AMR	17-21 October	Shelley	S&ID, NASA
Design concept meeting	Houston, Texas	18-19 October	Johnson	S&ID, NASA
PERT team meeting	Downey, California	18-19 October	Adams, Welsh	S&ID, NASA
Telecommunications meeting	Cedar Rapids, Iowa	18-20 October	Robinson	S&ID, NASA
Facilities funding meeting	Houston, Texas	18-22 October	Slauton, Wilkinson	S&ID, NASA
Docking simulation coordination	Columbus, Ohio	18-27 October	Bohlen, Barnes, Garton, Pearce	S&ID, NAA-Columbus
Fuel cell technical coordination	Downey, California	19 October	Feltz	S&ID, Pratt & Whitney
Contract negotiation Coordination meeting	East Hartford, Connecticut Cleveland, Ohio	20-24 October	Nash	S&ID, Pratt & Whitney S&ID, NASA, Clevite
Transponder requirements and recovery aids meeting	Washington, D. C. Dayton, Ohio	21-23 October	Dwinell	S&ID, NASA, USAF
Crew systems meeting	Houston, Texas	21-25 October	DeWitt	S&ID, NASA
Visual display systems meeting	Dayton, Ohio Akron, Ohio East Patterson, New Jersey New York, New York	21-26 October	Hatcher	S&ID, USAF S&ID, Goodyear Aircraft, Curtis-Wright Ferrend Optical Company, Inc.

Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
GSE technical and field analysis meeting	Hartford, Connecticut	21-26 October	Symons, Barker	S&ID, Pratt & Whitney
Survival equipment and procedures indoctrination	Houston, Texas	21-29 October	Smith	S&ID, NASA
Monthly coordination	Los Angeles, California	22 October	Richards, Parker, Reilly	S&ID, AiResearch
Biweekly electrical systems meeting	Houston, Texas	22-23 October	Nichols, Quebedeaux	S&ID, NASA
Technical progress discussion	Houston, Texas	22-23 October	Ryker	S&ID, NASA
GOSS coordination conference	Houston, Texas	22-24 October	Iongion, Clamy	S&ID, NASA
Electromagnetic interface coordination	Cambridge, Massachusetts	22-24 October	Beck, Frost, Curtin, Allen, Pumphrey	S&ID, MIT
Thermal properties and fabrication discussion	Newport News, Virginia	22-24 October	Gershun, Morant	S&ID, Langley
Monthly coordination	Hartford, Connecticut	22-26 October	Barker	S&ID, Pratt & Whitney
Biweekly electrical systems panel	Houston, Texas Lima, Ohio East Hartford, Connecticut	22-28 October	Champaign	S&ID, NASA, Westinghouse, Pratt & Whitney
Parachute drop test observations	El Centro, California	22 October 11 November	Ellis	S&ID, USN
Quarterly progress briefing	Houston, Texas	23-25 October	McCarthy	S&ID, NASA
Solar flare data discussion	Boulder, Colorado	23-25 October	Stazer	S&ID, High Altitude Observatory
Fuel cell power plant (temporary resident engineer)	East Hartford, Connecticut	23 October 1 November	Anderson	S&ID, Pratt & Whitney
Part task trainers discussion	Houston, Texas	24-25 October	Smith	S&ID, NASA
Parachute drop test preparation	El Centro, California	24-25 October	Young	S&ID, NASA
Biweekly systems meeting	Houston, Texas	24-25 October	Peterson, Kennedy, Jansen	S&ID, NASA
Data systems funding approval	Houston, Texas	24-26 October	Rutkowski	S&ID, NASA

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Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
Specifications review	Los Angeles, California	25 October	Flynn	S&ID, Aerojet
Fuel cell meeting	Houston, Texas	25-26 October	Nash	S&ID, NASA
Project integration coordination	Houston, Texas	25 October 9 November	Pacillo	S&ID, NASA
Docking simulation coordination	Columbus, Ohio	28 October	Oglevie	S&ID, NAA-Columbus
Boost vehicle coordination	Huntsville, Alabama	28-31 October	Tutt	S&ID, NASA
Chamber capabilities meeting	Tullahoma, Tennessee	28-31 October	Shure	S&ID, NASA
Component handling procedures review	Houston, Texas	28 October 2 November	Barmore	S&ID, NASA
Soldering specifications review	Los Angeles, California	29 October	Grule	S&ID, AiResearch
Facilities requirement review	Houston, Texas	29 October	Mundy, Dieterle	S&ID, NASA
Telecommunication design conference	Downey, California	29 October	Pope	S&ID, Collins Radio
Chamber capability review	Philadelphia, Pennsylvania	29-31 October	Altenbernd	S&ID, NASA, GE, AEDC
Interface discussion	Houston, Texas	29 October 1 November	DeWitt	S&ID, Hamilton Standard
Fuel handling systems meeting	AMR	29 October 3 November	Janus	S&ID, NASA
Vibrations discussion	Wichita, Kansas	29 October 1 November	Hornick	Symposium
Parachute drop test coordination	El Centro, California	29 October 26 November	Young	S&ID, USN
Facilities buildup coordination and pad abort requirements	White Sands, New Mexico	29 October 20 November	Bendees	S&ID, NASA
Quality control problems meeting	Huntsville, Alabama	30 October	Simmons	S&ID, NASA
Wind tunnel tests	Hampton, Virginia	30 October	Gillies, McNary	S&ID, Langley Research Center
Test facilities support approval	Las Cruces, New Mexico	30-31 October	Gatewood, Holmes, Sweeney, Proctor	S&ID, NASA
Subcontractor coordination	Elkton, Maryland	30 October 1 November	Bergeron	S&ID, Thiokol

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Table A-1. S&ID Apollo Meetings and Trips, October, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organization
Data system funding approval	Houston, Texas	30 October 2 November	Ferrier, Britton	S&ID, NASA
Spacesuit coordination	Houston, Texas Boston, Massachusetts	30 October	Tarr, Relly, Walkover, Stoll Brockman, Ross	S&ID, NASA
Ground support system and GSE design meeting	Houston, Texas Tulsa, Oklahoma	30 October 2 November	Regan, Fellows, Robertson, Mercier	S&ID, NASA
Appendix A review	Las Cruces, New Mexico	30 October 2 November	Bailey	S&ID, NASA
Biweekly GSE meeting	Houston, Texas	30 October 3 November	Pomykata, Regan	S&ID, NASA
Crew safety systems coordination	Huntsville, Alabama Houston, Texas	30 October 3 November	Dodds, Jacobson	S&ID, NASA
Powers system meeting subscale test program	Houston, Texas Tullahoma, Tennessee	30 October 10 December	Nakamura	S&ID, NASA, AEDC
Logistics requirements meeting	Azusa, California	31 October	Madison	S&ID, Aerojet
Technical interchange meeting	Wilmington, Massachusetts	31 October 2 November	Hanafin, Cook, Morant	S&ID, AVCO
Wind tunnel program	Houston, Texas	31 October	Allen	S&ID, NASA
Telemetering and instrumentation checkout review	Houston, Texas	31 October 2 November	Colwell	S&ID, NASA
Status briefing	Houston, Texas Huntsville, Alabama	31 October 2 November	McCarthy	S&ID, NASA

APPENDIX B

APOLLO PMP MILESTONES

Table B-1. Apollo PMP Milestones

Stabilization and Control Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
30-002-D	Complete - Spacecraft Stabilization and Control System - Requirements Definition	5 Nov 62	

Table B-1. Apollo PMP Milestones

Crew Provisions

Event No.	Milestone Description	Date	
		Schedule	Actual
31-129-D	Start - Development of Life Systems Program for Mock-ups and House Spacecraft Tests	14 Sept 62	1 Oct 62
31-103-D	Start - Analysis of Human Factors Requirements for Crew Operations Controls and Displays	21 Sept 62	1 Oct 62
31-107-D	Start - Establishment of Life Systems Criteria for Sub-contractor Design of Controls and Displays	21 Sept 62	1 Oct 62
31-147-D	Start - Human Engineering Tests of Mock-ups and House Spacecraft	28 Sept 62	1 Oct 62
31-019-D	Start - Evaluation Tests of Crew Support Equipment Materials	1 Oct 62	1 Oct 62
31-031-D	Start - Design Evaluation of Crew Accessories, Clothing, Tools, and Survival Equipment	1 Oct 62	1 Oct 62
31-056-D	Complete - Design Evaluation of Crew Compartment Interior Lighting	8 Oct 62	
31-121-D	Start - Analysis of Ground Crew Tasks and Performance Requirements	12 Oct 62	15 Oct 62
31-009-D	Start - Preparation of Waste Management Fixtures Design for Boilerplate 14 House Spacecraft	15 Oct 62	

Table B-1. Apollo PMP Milestones

Crew Provisions (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
31-022-D	Complete - Release of Design of Crew Support Equipment	26 Oct 62	
31-034-D	Complete - Release of Layout and Preliminary Design of Crew Accessories and Survival Equipment	26 Oct 62	
31-061-D	Start - Establishment of Final Design Criterial for Crew Compartment Interior Lighting	28 Oct 62	
31-095-D	Start - Digital Programming of Task Analysis Data	1 Nov 62	
31-099-D	Start - Analysis of Crew Duty Stations Work Load	1 Nov 62	
31-114-D	Complete - Establishment of Organization and Procedures for Coordinated Review and Resolution of Safety Problems	1 Nov 62	
31-135-D	Start - Crew Support (Couch, Suspension and Restraint) Human Engineering	1 Nov 62	
31-137-D	Start - Part Mission Crew Performance Simulation Tests	1 Nov 62	
31-010-D	Complete - Release of Waste Management Fixtures Design for Boilerplate 14 House Spacecraft	2 Nov 62	
31-046-D	Complete - Design of Flight Crew Display Panels for Mock-up 18	15 Nov 62	

Table B-1. Apollo PMP Milestones

Crew Provisions (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
31-052-D	Complete - Release of Design of Crew Compartment Interior Lighting Fixtures for Mock-up 18	15 Nov 62	
31-077-D	Start - Investigation of Biomedical Aspects of Crew Work-Rest Cycles	15 Nov 62	
31-089-D	Start - Medical Monitoring of Simulation and Tests	15 Nov 62	

Table B-1. Apollo PMP Milestones

Launch Escape Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
32-026-D	Complete - Pyrogen Test for Launch Escape Motor - Lockheed	26 Oct 62	
32-021-D	Start - Jettison Motor Development Tests - Thiokol	30 Oct 62	
32-010-D	Start - Fabrication of First Launch Escape System Static Test Tower	2 Nov 62	
32-027-D	Complete - Pyrogen Test for Tower Jettison Motor - Thiokol	8 Nov 62	
32-058-P	Complete - Delivery Tower Jettison Motor (Inert, Non-Fireable) Boilerplate 9	9 Nov 62	
32-071-P	Complete - Delivery Launch Escape Motor (Inert, Non-Fireable) Boilerplate 9	16 Nov 62	
32-011-D	Start - Launch Escape Development Motor Tests - Lockheed	29 Nov 62	

Table B-1. Apollo PMP Milestones

Environmental Control Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
33-047-D	Complete - Cryogenic Gas Storage System 100 Percent Design Release	15 Oct 62	
33-068-D	Complete - Detail Design Drawings Development ECS/GSE	25 Oct 62	
33-005-D	Complete - ECS Reliability Plan	31 Oct 62	
33-006-D	Complete - ECS Component Vendor Selection	31 Oct 62	
33-007-D	Complete - ECS Final Manufacturing Plan	31 Oct 62	
33-061-D	Complete - Boilerplate ECS Special System Component Tests	1 Nov 62	
33-020-D	Complete - Preliminary Breadboard Coldplate Design Release	6 Nov 62	
33-031-D	Complete - Fabricate Space Radiator Breadboard Test	12 Nov 62	
33-069-D	Complete - Fabrication and Assembly Development ESC/GSE	12 Nov 62	
33-008-D	Complete - ECS 100 Percent Design Release for Boilerplates	14 Nov 62	
33-021-D	Complete - Coldplate Breadboard Tests	15 Nov 62	
33-070-D	Complete - ECS Component Test With GSE Component Test Stand Development GSE	16 Nov 62	

Table B-1. Apollo PMP Milestones

Environmental Control Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
33-071-D	Complete - Subsystem Development With Console Development ESC/GSE	22 Nov 62	
33-022-D	Complete - 100 Percent Coldplate Design Release	23 Nov 62	
33-032-D	Complete - 100 Percent Space Radiator Design Release	23 Nov 62	
33-072-D	Complete - 100 Percent Drawing Release Production ESC/GSE	23 Nov 62	

Table B-1. Apollo PMP Milestones

Earth Landing Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
34-004-D	Complete - Design and Development Parachute Test Vehicle	9 Oct 62	18 Oct 62
34-020-D	Complete - Design and Development Drogue-Chute System (4 Tests)	27 Oct 62	
34-028-D	Complete - Sequence Control Design - Recovery System	30 Oct 62	
34-009-D	Start - Single Chute Development Testing	1 Nov 62	
34-023-D	Start - Drogue Wind Tunnel Tests	15 Nov 62	
34-021-D	Start - Drogue Development and Design Verification Tests	18 Nov 62	

Table B-1. Apollo PMP Milestones

Communications Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
35-001-D	Complete - Preliminary Systems Specifications & Design Criteria VHF/FM Transmitter	1 Nov 62	
35-002-D	Complete - Equipment Specifications Approval VHF/FM Transmitter	1 Nov 62	
35-003-D	Complete - Preliminary Design VHF/FM Transmitter	1 Nov 62	
35-006-D	Complete - Equipment Specifications Approval VHF/AM Transceiver	1 Nov 62	
35-009-D	Complete - Equipment Specifications Approval Deep Space Instrumentation Facility Transponder	1 Nov 62	
35-013-D	Complete - Equipment Specifications Approval Deep Space Instrumentation Facility Power Amplifier	1 Nov 62	
35-016-D	Complete - Equipment Specifications Approval Very High Frequency Recovery Beacon	1 Nov 62	
35-021-D	Complete - Equipment Specifications Approval High Frequency Transceiver	1 Nov 62	
35-022-D	Complete - Preliminary Design High Frequency Transceiver	1 Nov 62	
35-025-D	Complete - Equipment Specifications Approval C-Band Transponder	1 Nov 62	

Table B-1. Apollo PMP Milestones

Communications Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
35-030-D	Complete - Equipment Specifications Approval Television	1 Nov 62	
35-035-D	Complete - Equipment Specifications Approval Telemetry Equipment	1 Nov 62	
35-040-D	Complete - Equipment Specifications Approval Signal Conditioner	1 Nov 62	
35-041-D	Complete - Preliminary Design Signal Conditioner	1 Nov 62	
35-044-D	Complete - Equipment Specifications Approval Data Patch Panel	1 Nov 62	
35-045-D	Complete - Preliminary Design Data Patch Panel	1 Nov 62	
35-048-D	Complete - Equipment Specifications Approval Inter-communications	1 Nov 62	
35-051-D	Complete - Equipment Specifications Approval Controls and Displays	1 Nov 62	
35-052-D	Complete - Preliminary Design Controls and Displays	1 Nov 62	
35-055-D	Complete - Equipment Specifications Approval 2KMC Omni-Antenna	1 Nov 62	
35-056-D	Complete - Preliminary Design 2KMC Omni-Antenna	1 Nov 62	

Table B-1. Apollo PMP Milestones

Communications Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
35-058-D	Complete - Component Specifications Approval Non-Reentry Radome	1 Nov 62	
35-059-D	Complete - Subcontractor Selection Approval Non-Reentry Radome	1 Nov 62	
35-067-D	Complete - Equipment Specifications Approval Backup Very High Frequency Recovery Antenna	1 Nov 62	
35-069-D	Complete - Equipment Specifications Approval Reentry Telemetering Radome	1 Nov 62	
35-071-D	Complete - Equipment Specifications Approval C-Band Antenna	1 Nov 62	
35-072-D	Complete - Preliminary Design C-Band Antenna	1 Nov 62	
35-010-D	Complete - Subcontractor Selection Approval Deep Space Instrumentation Facility Transponder	15 Nov 62	
35-017-D	Complete - Subcontractor Selection Approval Very High Frequency Recovery Beacon	15 Nov 62	
35-018-D	Complete - Preliminary Design Very High Frequency Recovery Beacon	15 Nov 62	

Table B-1. Apollo PMP Milestones

Communications Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
35-026-D	Complete - Subcontractor Selection Approval C-Band Transponder	15 Nov 62	
35-027-D	Complete - Preliminary Design C-Band Transponder	15 Nov 62	
35-074-D	Complete - Equipment Specifications 2KMC High Gain Antenna	15 Nov 62	

Table B-1. Apollo PMP Milestones

Command Module Structure & Subsystem Installation

Event No.	Milestone Description	Date	
		Schedule	Actual
37-226-P	Complete - Manufacturing Command Module (Boilerplate 1)	1 Oct 62	
37-116-D	Complete - Airframe Command Module Crew Couch Mechanisms Design Criteria	12 Oct 62	
37-239-P	Complete - Assembly Command Module Structure (Boilerplate 3)	20 Oct 62	
37-074-D	Complete - Boilerplate 14 Command Module Structure Design	26 Oct 62	
37-131-D	Complete - Airframe Command Module Definitions of Substructure & Ablative Material Attachment	26 Oct 62	
37-237-P	Complete - Assembly Command Module Structure (Boilerplate 2)	1 Nov 62	
37-016-D	Complete - Command Module Mechanisms, Basic Study	2 Nov 62	
37-066-D	Complete - Boilerplate 12 Command Module Structure Drawing Release	2 Nov 62	
37-099-D	Complete - Boilerplate 15 Command Module Structure Drawing Release	2 Nov 62	
37-115-D	Complete - Airframe Command Module Crew Couch Mechanisms Basic Study	2 Nov 62	

Table B-1. Apollo PMP Milestones

Command Module Structure & Subsystem Installation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
37-121-D	Complete - Airframe Command Module Mechanisms Basic Study	2 Nov 62	
37-072-D	Complete - Boilerplate 13 Command Module Structure Drawing Release	9 Nov 62	
37-085-D	Complete - Boilerplate 23 Command Module Structure Drawing Release	9 Nov 62	
37-132-D	Complete - Airframe Command Module Definitions of Ablative Heat Shield Tile Plane Geometry (Avco)	15 Nov 62	
37-076-D	Complete - Boilerplate 14 Command Module Structure Drawing Release	19 Nov 62	
37-241-P	Complete - Assembly Command Module Structure (Boilerplate 6)	20 Nov 62	
37-255-P	Complete - Assembly Command Module Structure (Boilerplate 19)	25 Nov 62	

Table B-1. Apollo PMP Milestones

Service Propulsion Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
38-004-D	Complete - Preliminary Drawings for Gimbal Actuators	24 Sept 62	2 Oct 62
38-030-D	Complete - Procurement Specifications for Gimbal Actuators	24 Sept 62	2 Oct 62
38-003-D	Complete - Thrust Mount Design	10 Oct 62	11 Oct 62
38-005-D	Complete - GSE Specifications (Rocket Engine)	30 Oct 62	
38-049-D	Complete - Firm Basic Configuration Propellant Feed System	1 Nov 62	
38-050-D	Start - Propellant Feed Studies	1 Nov 62	
38-023-D	Complete - Spacecraft Interface Establishment	15 Nov 62	
38-025-D	Complete - 100 Percent Design Release Test Fixture Preflight Rating Test	15 Nov 62	

Table B-1. Apollo PMP Milestones

Service Module Structure and Subsystem Installation

Event No.	Milestone Description	Date	
		Schedule	Actual
39-003-D	Complete - Design of Service Module Boilerplate Separation System		11 Oct 62
39-102-P	Complete - Assembly Service Module Structure Boilerplate 12	5 Oct 62	
39-021-D	Complete - Service Module Boilerplate 14 Structure Drawing Release	16 Nov 62	
39-010-D	Complete - Service Module Boilerplate 9 Assembly and Installation Drawings Release Separation System	30 Nov 62	
39-018-D	Complete - Service Module Boilerplate 13 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-034-D	Complete - Service Module Boilerplate 15 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-038-D	Complete - Service Module Boilerplate 16 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-042-D	Complete - Service Module Boilerplate 18 Assembly and Installation Drawing Release Separation System	30 Nov 62	

Table B-1. Apollo PMP Milestones

Electrical Power Subsystems

Event No.	Milestone Description	Date	
		Schedule	Actual
40-004	Complete - BP-6 Sequencing System Breadboard Evaluation Tests		15 Oct 62
40-005-D	Complete - Reliability Survey of Boilerplate 6 Sequencing System Components		15 Oct 62
40-006-D	Complete - Product Design Release Boilerplate 6 Sequencing System		15 Oct 62
40-055-D	Complete - Boilerplates, 13, 15, 16, and 18 Circuit Design Sequencing System Approved by NASA	17 Sept 62	1 Oct 62
40-078-D	Complete - Release Battery Final Specifications	21 Sept 62	8 Oct 62
40-028-D	Complete - Boilerplate 22 Circuit Design Sequencing System	24 Sept 62	7 Oct 62
40-041-D	Complete - Boilerplate 12 and Boilerplate 23 Circuit Design Sequencing System	26 Sept 62	10 Oct 62
40-042-D	Complete - Boilerplate 12 and Boilerplate 23 Circuit Design Sequencing System Approved by NASA	1 Oct 62	15 Oct 62
40-066-D	Complete - Battery Charger Final Specification	1 Oct 62	15 Oct 62
40-079-D	Complete - Battery Subcontract Award	11 Oct 62	26 Oct 62

Table B-1. Apollo PMP Milestones

Electrical Power Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
40-056-D	Complete - Boilerplates 13, 15, 16, and 18 Sequencing System Breadboard Evaluation Tests	25 Oct 62	
40-225-D	Complete - Fuel Cell Preliminary Test Review	25 Oct 62	
40-014-D	Complete - Airframes 2, 9, 10 and 11 Sequencing System Requirements Definition	1 Nov 62	
40-029-D	Complete - Boilerplate 22 Circuit Design Sequencing System Approved by NASA	1 Nov 62	
40-057-D	Complete - Reliability Survey of Boilerplates 13, 15, 16, and 18 Sequencing System Components	1 Nov 62	
40-058-D	Complete - Product Design Release Boilerplates 13, 15, 16, and 18 Sequencing System	1 Nov 62	
40-067-D	Complete - Battery Charger Subcontract Award	1 Nov 62	
40-154-D	Complete - Release Hot Wire Initiator Final Specification	1 Nov 62	
40-235-D	Complete - Fuel Cell Radiator Preliminary Design	1 Nov 62	
40-142-D	Complete - Release Explosive Bridge Wire Initiator Final Specification	9 Nov 62	

Table B-1. Apollo PMP Milestones

Electrical Power Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
40-202-D	Complete - Release Explosive Bridge Wire Firing Unit Preliminary Specification	15 Nov 62	
40-059-D	Complete - Boilerplates 13, 15, 16, and 18 Sequencing System Design Approval by Range Safety Officer	20 Nov 62	

Table B-1. Apollo PMP Milestones

Reaction Control Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
41-027-T	Start - AEDC Phase I Tests	24 Sept 62	8 Oct 62
41-048-D	Start - Engine Thrust Chamber Tests (Command Module)	1 Nov 62	
41-035-D	Start - Prototype Engine Development Tests (Service Module)	12 Nov 62	
41-001-D	Complete - Release of Reaction Control System Equipment Procurement Specifications (Command Module)	15 Nov 62	
41-002-D	Complete - Release of Reaction Control System Equipment Procurement Specifications (Service Module)	15 Nov 62	

Table B-1. Apollo PMP Milestones

Spacecraft Adapters

Event No.	Milestone Description	Date	
		Schedule	Actual
42-068-D	Start - Basic Study Attach and Release Mech. AFRM	1 Oct 62	
42-105-P	Complete - Assembly Structure Adapter Boilerplate 12	1 Oct 62	
42-040-D	Complete - Adapter Design Criteria Boilerplate 14	26 Oct 62	
42-044-D	Complete - Adapter Structure Design Boilerplate 14	26 Oct 62	
42-045-D	Start - Adapter Drawing Release Boilerplate 14	16 Nov 62	

Table B-1. Apollo PMP Milestones

Command Module and Service Module Ground Support Equipment

Event No.	Milestone Description	Date	
		Schedule	Actual
43-007-D	Complete - Handling GSE Design Boilerplate 3	22 Oct 62	
43-008-D	Complete - Auxiliary GSE Design Boilerplate 3	22 Oct 62	
43-014-D	Complete - Handling GSE Design Boilerplate 3	26 Oct 62	
43-021-D	Complete - Handling GSE Design Boilerplate 6	1 Nov 62	
43-030-D	Complete - Handling GSE Design Boilerplate 13	9 Nov 62	
43-004-D	Complete - GSE Concept Boilerplates 3 and 19	15 Nov 62	
43-020-D	Complete - GSE List Boilerplates 6, 12, 22, and 23	19 Nov 62	

Table B-1. Apollo PMP Milestones

Training and Trainers

Event No.	Milestone Description	Date	
		Schedule	Actual
25-034-D	Complete - Navigation and Trajectory Trainer Engineering Development Report	5 Oct 62	5 Oct 62
25-022-D	Complete - Earth Launch and Reentry Trainer Engineering Development Report	1 Nov 62	5 Oct 62
25-028-D	Complete - Orbital and Rendezvous Trainer Engineering Development Report	1 Nov 62	5 Oct 62

Table B-1. Apollo PMP Milestones

Instrumentation

Event No.	Milestone Description	Date	
		Schedule	Actual
24-016-D	Complete - Receipt of Data on Vibration Sensors Boilerplate 6	1 Jan 62	1 Oct 62
24-017-D	Complete - Receipt of Data on Pressure Sensors Boilerplate 6	1 Jan 62	1 Oct 62
24-018-D	Complete - Receipt of Data on Temperature Sensors Boilerplate 6	1 Jan 62	1 Oct 62
24-021-D	Complete - Receipt of Data on Attitude Gyro Boilerplate 6	1 Jan 62	1 Oct 62
24-024-D	Complete - Receipt of Data on Power Control Buy Boilerplate 6	1 Jan 62	1 Oct 62
24-025-D	Complete - Receipt of Data on Main Battery Boilerplate 6	1 Jan 62	1 Oct 62
24-026-D	Complete - Receipt of Data on Pyro Battery Boilerplate 6	1 Jan 62	1 Oct 62
24-027-D	Complete - Receipt of Data on Junction Box Boilerplate 6	1 Jan 62	1 Oct 62
24-031-D	Complete - Receipt of Data on Direct Current Amplifier Racks Boilerplate 6	1 Jan 62	1 Oct 62
24-061-D	Complete - Receipt of Data on Main Battery Boilerplate 12	1 Feb 62	1 Oct 62
24-062-D	Complete - Receipt of Data on Pyro Battery Boilerplate 12	1 Feb 62	1 Oct 62

Table B-1. Apollo PMP Milestones

Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-067-D	Complete - Receipt of Data on Direct Current Amplifier Racks Boilerplate 12	1 Feb 62	1 Oct 62
24-072-D	Complete - Measurement Requirements Study Boilerplate 13	1 June 62	1 Oct 62
24-008-D	Complete - Receipt of Data on Telemetry Sub-Carrier Assembly Boilerplate 6	1 Nov 62	
24-009-D	Complete - Receipt of Data on Telemetry Radio Frequency Assembly Boilerplate 6	1 Nov 62	
24-010-D	Complete - Installation Design of Telemetry Measuring Equipment Boilerplate 6	1 Nov 62	
24-012-D	Complete - Receipt of NASA Data on Data Storage Equipment Boilerplate 6	1 Nov 62	
24-013-D	Complete - Installation Design of Data Storage Equipment Boilerplate 6	1 Nov 62	
24-015-D	Complete - Receipt of Data on Acceleration Sensors Boilerplate 6	1 Nov 62	
24-019-D	Complete - Receipt of Data on Timer Boilerplate 6	1 Nov 62	
24-020-D	Complete - Receipt of Data on Rate Gyro Boilerplate 6	1 Nov 62	

Table B-1. Apollo PMP Milestones

Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-022-D	Complete - Installation Design of Sensor Equipment Boilerplate 6	1 Nov 62	
24-030-D	Complete - Receipt of Data on Signal Conditioner Box Boilerplate 6	1 Nov 62	
24-032-D	Complete - Receipt of Data on Direct Current Amplifier Boilerplate 6	1 Nov 62	
24-033-D	Complete - Installation Design of Signal Conditioner Equipment Boilerplate 6	1 Nov 62	
24-034-D	Complete - Inspection and Calibration of Instruments Boilerplate 6	1 Nov 62	
24-051-D	Complete - Receipt of Data on Acceleration Sensors Boilerplate 12	1 Nov 62	
24-052-D	Complete - Receipt of Data on Statham Pressure Sensors Boilerplate 12	1 Nov 62	
24-006-D	Complete - Manufacture of Q Ball Boilerplate 6	15 Nov 62	

Table B-1. Apollo PMP Milestones

Spacecraft Test Operations - Downey

Event No.	Milestone Description	Date	
		Schedule	Actual
26-051-T	Complete - Detailed Test Plan for Boilerplate 13/SA-6	1 Nov 62	
26-044-T	Complete - Detailed Test Plan for Maximum Q Abort Test of Boilerplate 23	15 Nov 62	

Table B-1. Apollo PMP Milestones

Facilities

Event No.	Milestone Description	Date	
		Schedule	Actual
46-003-F	Complete - MSC Approval of Data Ground Station A & E Design Development Criteria	27 Aug 62	5 Oct 62
46-120-F	Complete - Propulsion Systems Development Facility A & E Design Development	1 Oct 62	
46-050-F	Complete - A & E Design of Systems Integration and Checkout Facility Site and Foundation	5 Oct 62	
46-055-F	Complete - Systems Integration and Checkout Facility Structural Steel Design	5 Oct 62	
46-121-F	Complete - MSC Approval of Propulsion Systems Development Facility A & E Design	11 Oct 62	
46-051-F	Complete - MSC Appproval of A & E Design of Systems Integration and Checkout Facility Site and Foundation	15 Oct 62	
46-056-F	Complete - MSC Approval of Systems Integration and Checkout Facility Structural Steel Design	15 Oct 62	
46-114-F	Complete - Award of Impact Test Facility Construction Contract	17 Oct 62	
46-115-F	Start - Impact Test Facility Construction	20 Oct 62	

Table B-1. Apollo PMP Milestones
Facilities (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
46-004-F	Complete - Award of Data Ground Station A & E Contract	24 Oct 62	
46-016-F	Complete - Bonding and Test Facility A & E Design	24 Oct 62	
46-072-F	Complete - Award of Space Systems Development Facility Enviromental Control Building A & E Contract	27 Oct 62	
46-081-F	Complete - Award of Space Systems Development Facility Reaction Control	27 Oct 62	
46-090-F	Complete - Award of Space Systems Development Facility A & E Contract	27 Oct 62	
46-068-F	Complete - Systems Integration and Checkout Facility Construction	29 Oct 62	
46-033-F	Complete - Award of Plaster Master Facility Construction Contract	1 Nov 62	
46-017-F	Complete - MSC Approval of Bonding and Test Facility A & E Design	3 Nov 62	
46-034-F	Start - Plaster Master Facility Construction	7 Nov 62	
46-116-F	Start - Impact Test Facility Structural Steel Erection	9 Nov 62	

Table B-1. Apollo PMP Milestones

Facilities (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
46-129-F	Complete - MSC Approval of A & E Design of Propulsion Systems Development Facility Service Module Test Stand Complex	9 Nov 62	
46-042-F	Complete - Award of Radiographic Facility Construction Contract	10 Nov 62	
46-043-F	Start - Radiographic Facility Construction	17 Nov 62	
46-122-F	Complete - Award A & E Contract for Design of Propulsion Systems Development	23 Nov 62	
46-148-F	Complete - MSC Approval of Propulsion Systems Development Facility Combined Systems Test Stand Complex	23 Nov 62	
46-060-F	Complete - Systems Integration and Checkout Facility A & E Design	30 Nov 62	

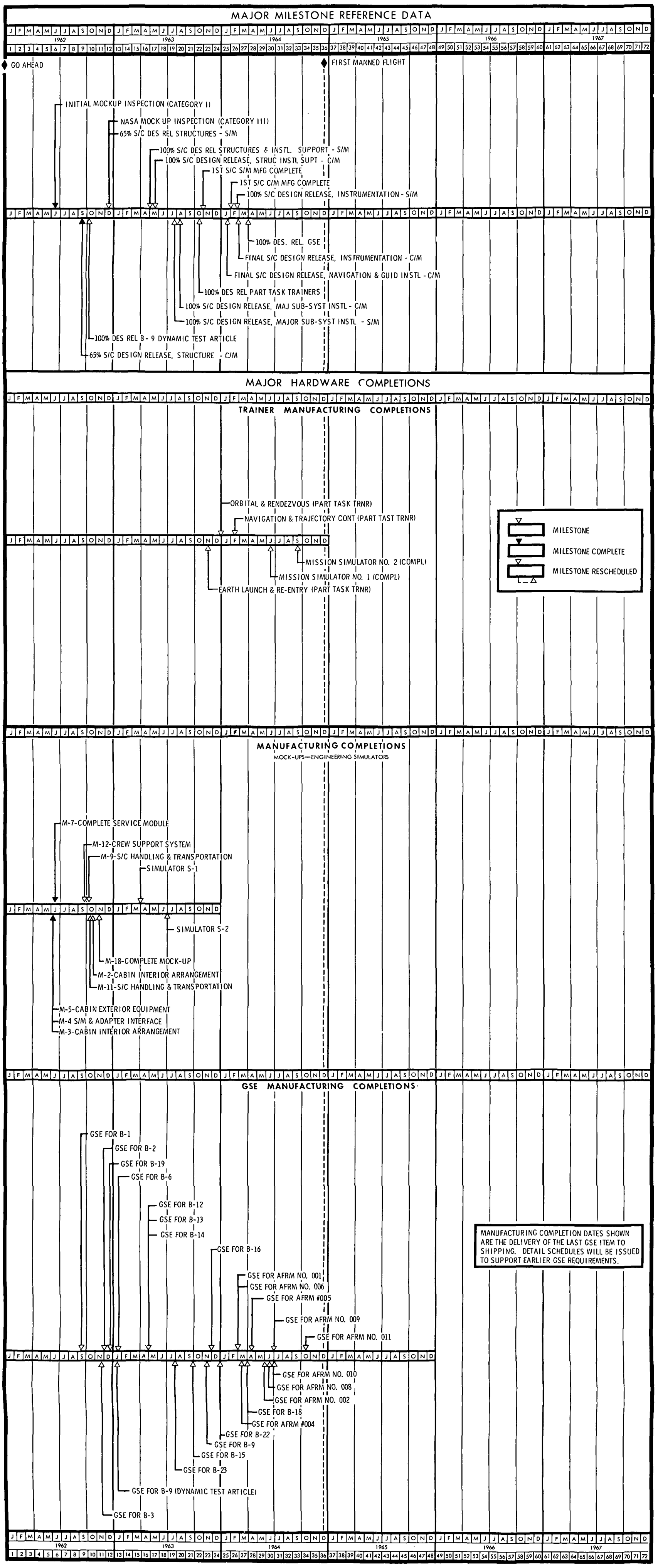
Table B-1. Apollo PMP Milestones

Flight Technology

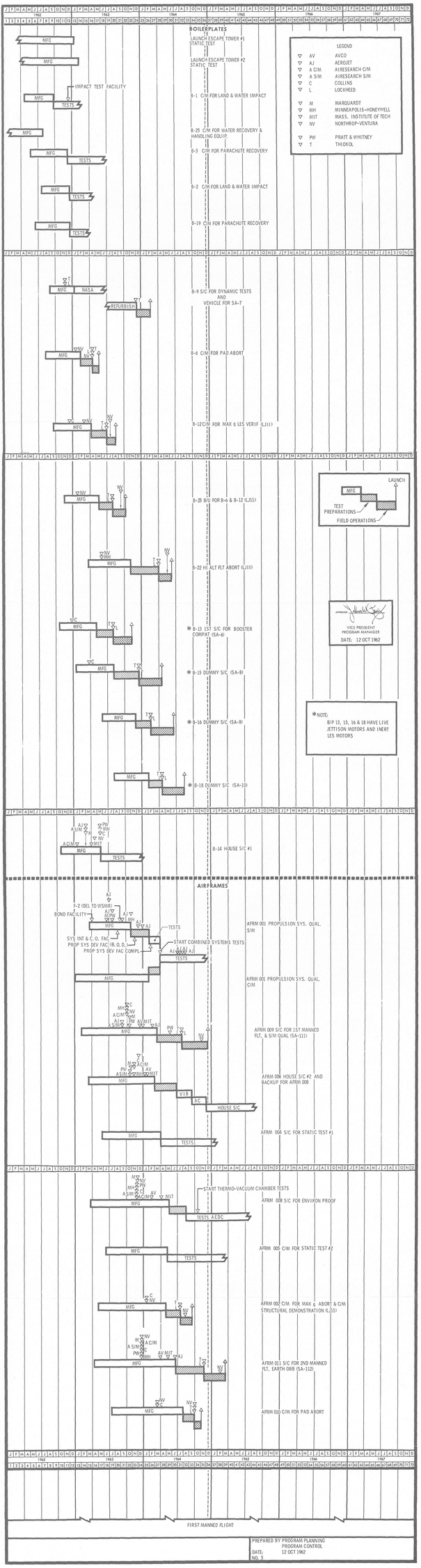
Event No.	Milestone Description	Date	
		Schedule	Actual
21-079-D	Complete - Preliminary Space Radiator Design Requirements	31 Aug 62	1 Oct 62
21-081-D	Complete - Preliminary Thermal Radiation Coating Determined	31 Aug 62	1 Oct 62
21-019-D	Complete - Preliminary Command Module Aerodynamic Analysis	1 Nov 62	
21-077-D	Complete - Preliminary ECS Optimization	1 Nov 62	
21-080-D	Complete - Final Space Radiator Design Requirements	1 Nov 62	
21-084-D	Complete - Fuel Cell Prototype Preliminary Performance Analysis	1 Nov 62	
21-076-D	Complete - Fuel Cell GSE Requirements	2 Nov 62	
21-018-T	Complete - Flight Test Program Report for Aerodynamics	30 Nov 62	
21-022-D	Complete - Launch Escape System Jet Effect Wind Tunnel Test	30 Nov 62	

APPENDIX C

APOLLO MASTER DEVELOPMENT SCHEDULE



Apollo Master Development Schedule (Part I)



Apollo Master Development Schedule (Part II)

NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION